SeaShark

Detailed Design Document

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Summary: SeaShark will provide a capability to process, archive and disseminate data acquired by the Seastar SeaWiFS and NOAA AVHRR sensors.

Authors: C.L Aspell, S.J. Newby, J.E. Rickards, J. Mitchell, M.R. Lever, J.W. Treloar (VEGA)

Signed: [S.J. Newby] ..... Date:

Reviewed: [T. Stephens] ..... Date:

Authorized: [C.P. Winder] ..... Date:

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1 INTRODUCTION

1.1 Purpose

To document the detailed design of the SeaShark software.

This document is intended to be read by parties interested in the software development of SeaShark, including:

- ESRIN, which wishes to ensure that the software will encompass a complete and consistent set of functions;
- VEGA, the developer of SeaShark, which wishes to ensure that the scope of the software is well-defined and that the software will be testable.

1.2 Scope

The SeaShark project will develop software to provide a capability for the processing, archiving and dissemination of data from the SeaStar and NOAA satellites. The software will be installed at several acquisition stations of the European Co-ordinated Tiros Network; it will provide an environment in which the data processing can be easily carried out by trained operators on a regular basis.

1.3 Definitions, Acronyms and Abbreviations

This section lists the definitions of all terms, acronyms and abbreviations, or refer to other documents where the definitions can be found.

Term	Definition
ADD	Architectural Design Document
AQTIM	AcQuisition TIMe
APT	Automatic Picture Transmission
AVHRR	Advanced Very High Resolution Radiometer
BPI	Bits Per Inch
CCT	Computer Compatible Tape
CEOS	Committee on Earth Observation Satellites
DCW	Digital Chart of the World
ECTN	ESRIN Co-ordinated TIROS Network
EPOORD	Earthnet Programme Office
ESA	European Space Agency
ESRIN	European Space Research INstitute
FDP	Fast Delivery Product
GIF	Graphics Interchange Format
GUI	Graphical User Interface
HRPT	High Resolution Picture Transmission
IDL	Interactive Data Language (visualisation software)

Table 1-1 Definition of Terms

Term	Definition
LAC	Local Area Coverage
MMDD	Multi-Mission Data Dissemination
NASA	National Aeronautics and Space Administration
NDVI	Normalised Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
OD	Optical Disc
OSC	Orbital Sciences Corporation
OSF	Open Software Foundation
PML	Plymouth Marine Laboratory (UK)
SeaWiFS	Sea-Viewing Wide Field-of-View Sensor
SCSI	Small Computer Systems Interface
SHARK	Station HRPT Archiving and Reprocessing Kernel
SHARP	Standard HRPT Archive and Request Product
SIUF	SeaWiFS Inventory Update Format
SST	Sea Surface Temperature
TIROS	Television and Infra-Red Observation Satellite
URD	User Requirements Document
SRD	Software Requirements Document

Table 1-1 Definition of Terms

1.4 References

The following is a list of documents with a direct bearing on the content of this report. Where referenced in the text, these are identified as [*n*], where *n* is the number in the list below.

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[3] ESA Software Engineering Standards, ESA PSS-05-0, Issue 2, February, 1991

[4] SeaShark User Requirements Document, SHK.URD.002, Issue 2, 13 January 1994.

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[26] EO Formatting System, Inventory Exchange Format, SeaWiFS Inventory Update File (SIUF) Specification, EOFS-IEF-002-TN-2.2, 2 March, 1995.

[27] SeaShark System Specifications, Annex A, DPE/OT/JMM/93-001 Issue 1.4.

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[29] SeaShark System Specifications, Reporting, DPE/OT/JMM/93-001 Issue1.4

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[32] Effective C++, Scott Meyers, Addison Wesley, ISBN 0-201-56364-9.

[33] The Annotated C++ Reference Manual, M.A.Ellis & B.Stroustrup, published by Addison-Wesley, 1990.

[34] Two Line Element Set Format Description, SPACECOM/NASA, date unknown.

[35] Tbus format, APT Information Note, February 1981.

[36] EPOORD/Ground Station Interface Specification, SH3-EPO-SER-00-006, Issue 3.2, 26 June, 1995.

[37] Orbit Stitching Philosophy, ESRIN fax, 27 March, 1995.

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[41] Tools.h++ Foundation Class Library for C++ Programming, Version 7, Rogue Wave Software Inc., 1996.

[42] SeaShark Instrument Data Product Format – FDP Generic Format, SHK.ICD.003, 27 November, 1996.

[43] SeaShark Instrument Data Product Format – SeaWiFS Flexible Format, SHK.ICD.004, 28 October, 1997.

[44] SeaShark SeaWiFS Level 2 Processing – Guide to Products, SHK.GTP.001, 9 February, 1998.

[45] HMF SeaWiFS HRPT Data Format, SHK.ICD.005, 17 June, 1999.

1.5 Overview

The document follows the guidelines laid down in the ESA Software Engineering Standards PSS-05-02 [3]. After this introduction, the document is divided into a number of major sections which are briefly described below:

2. GENERAL DESCRIPTION

This section outlines the standards which will apply to all software developed within the project.

3. PHYSICAL DESIGN

This section describes the physical design of SeaShark, i.e. how the system is divided into physical design elements, such as processes, and how those processes communicate with each other.

4. PROCESSING INTERFACE

Defines how SeaShark executes processing tasks. Some are automatic, others require operator intervention.

5. FILE FORMATS

Defines the file formats used within SeaShark.

6. PROCESSING STEPS

Describes the various stages of data processing which SeaShark is capable of.

7. COMPONENTS

This section gives an overview of the GUI and the modules and classes which make up the SeaShark software.

2 GENERAL DESCRIPTION

This section defines the standards which will apply to all software developed within the project.

2.1 Design Standards

Booch standards have been followed in the architectural design phase [13].

2.2 Documentation Standards

ESA standards will be followed [3].

2.3 Naming Conventions

The development directories of Table 2-1 will be used.

Directory	Contents
devsw	software under development (see below)
misc	miscellaneous files
Shadow	copy of latest software delivered to ESRIN
Test	test datasets

Table 2-1 Development Area Directory Structure

The software directories (devsw, Shadow) will be further sub-divided as in Table 2-2.

Directory	Contents
bin	executable files
config	configuration files
help	on-line help files
include	include files
install	installation scripts
lib	library files
src	source files

Table 2-2 Directory Structure of $SEASHARKHOME

A full analysis is presented in section 3.7 on page 19. The src sub-directory will be divided in a logical manner to the level of classes. A separate sub-directory is used to hold programs and processes. At the lowest level, separate directories will be used to hold RCS and test files.

The following naming conventions will be used in the SeaShark C++ source code:

- *Class names*. Each separate word of the class name will begin with an uppercase letter and the remaining characters of the word will be lowercase. Words be joined together. Words which represent acronyms in uppercase are allowed and will be written in uppercase. For example CEOSFileDescriptor.

- *File names*. The name of the file containing a class will be the same as the class name, except that each separate word will begin with a lowercase letter and words will be joined using the underscore character. For example CEOS_file_descriptor.cc.
- *Private data names*. Data which is private to a class will contain lowercase letters and will begin with an underscore character. Individual words will be separated by the underscore For example _document_number.
- *Method names*. Names of methods which access private data will be the same as the data name, except that each separate word will begin with an uppercase character and words will be joined. For example DocumentNumber. Further words can be used, if they further illustrate the nature of the method, for example GetDocumentNumber.
- *Libraries.* These will be named with the character string “lib” followed by the class name in lowercase letters. For example libcatalogue.a.

2.4 Programming Standards

Each source code file will include a standard module header as shown below:

```
//
//Title:  sensor.cc
//
//Project: SeaShark
//
//Type:C++
//
//Version:
//
//Author: David Palmer
//   Vega Group PLC.
//   Arden Grove
//   Harpenden
//   Hertfordshire
//   England
//   AL5 4SJ
//
//Date:   23.11.94
//
//Purpose:
//
//   Class used to represent a sensor (SeaWiFS or AVHRR) on board
//   a satellite.
//
//Comments:
//                    Not under RCS configuration.
//
//Known Bugs:
//   None.
//
//******************** #includes ********************************
//******************** constant definitions *********************
//******************** type definitions *************************
```

```
//******************** class declarations ***********************
//******************** variable definitions *********************
//--------------------- function declarations ---------------------
//--------------------- function definitions ----------------------
```

Before being placed in the devsw subdirectory the module header will be updated with the keywords necessary to bring the module under configuration control by the RCS package.

Debug statements will be used to print information which is useful in debugging. A VEGA standard DBG macro will be used which can be turned on or off when compiling the system.

Each module will be built using the Unix *make* facility. Recursive make files will be used.

C++ specific programming standards are listed in the table below. They are taken from [8] and [32]. They are divided into three types, rules (Rule.) which are mandatory, recommendations (Rec.) which are suggested and portability recommendations (Port. Rec.) which are specific recommendations aimed at ensuring portable code.

Rule	Description
Rule 0	Every time a rule is broken this must be clearly documented
Rule 1	Include files in C++ always have the file name extension
Rule 2	Implementation files in C++ always have the file name extension *.cc*
Rule 3	Inline definition files always have the file name extension *.icc*
Rule 4	Every file that contains source code must be documented with an introductory comment that provides information on the file name and its contents
Rule 5	All files must include copyright information
Rule 6	All comments are to be written in English
Rule 7	Every include file must contain a mechanism that prevents multiple inclusions of the file
Rule 8	When the following kinds of definitions are used in implementation files or in other include files they must be included as separate include files: classes that are used as base classes, classes that are used as member variables, classes that appear as return types or as argument types in function/member function prototypes, function prototypes for functions/member functions used in inline member functions that are defined in the file
Rule 9	Definitions of classes that are only accessed via pointers ***** or references **&** shall not be included as include files
Rule 10	Never specify relative UNIX names in **#include** directives
Rule 11	Every implementation file is to include the relevant files that contain: declarations of types and functions used in the functions that are implemented in the file; declarations of variables and member functions used in the functions that are implemented in the file
Rule 12	The identifier of every globally visible class enumeration type, type definition, function constant and variable in a class library is to begin with a prefix that is unique for the library
Rule 13	The names of variables, constants and functions are to begin with a lowercase letter
Rule 14	The names of abstract data types, structures, typedefs, and enumerated types are to begin with an uppercase letter
Rule 15	In names which consist of more than one word the words are written together and each word that follows the first is begun with an uppercase letter
Rule 16	Do not use identifiers which begin with one or two underscores
Rule 17	A name that begins with an uppercase letter is to appear directly after its prefix

Table 2-3 C++ Coding Rules

Rule	Description
Rule 18	A name that begins with a lowercase letter is to be separated from its prefix using an underscore
Rule 19	A name is to be separated from its suffix using an underscore
Rule 20	The **public**, **protected**, and **private** sections of a class are to be declared in that order (the public section is declared before the protected section which is declared before the private section).
Rule 21	No member functions are to be defined within the class definition
Rule 22	Never specify public member data in a class
Rule 23	A member function that does not affect the state of an object (its instance variables) is to be declared **const**
Rule 24	If the behaviour of an object is dependent on data outside the object this data is not to be modified by **const** member functions
Rule 25	A class which uses **new** to allocate instances managed by the class, must define a copy constructor
Rule 26	All classes which are used as base classes and which have virtual functions must define a virtual destructor
Rule 27	A class which uses **new** to allocate instances managed by the class, must define an assignment operator
Rule 28	An assignment operator which performs a destructive action must be protected from performing this action on the object upon which it is operating
Rule 29	A public member function must never return a non-const reference or pointer to member data
Rule 30	A public member function must never return a non-const reference or pointer to data outside an object, unless the object shares the data with other objects
Rule 31	Do not use unspecified function arguments (ellipsis notation)
Rule 32	The names of formal arguments to functions are to be specified and are to be the same both in the function declaration and in the function definition
Rule 33	Always specify the return type of a function explicitly
Rule 34	A public function must never return a reference or a pointer to a local variable
Rule 35	Do not use the preprocessor directive **#define** to obtain more efficient code; instead use inline functions
Rule 36	Constants are to be defined using **const** or **enum**, never using **#define**
Rule 37	Avoid the use of numeric values in code; use symbolic values instead
Rule 38	Variables are to be declared with the smallest possible scope
Rule 39	Each variable is to be declared in a separate declaration statement
Rule 40	Every variable that is declared is to be given a value before it is used
Rule 41	If possible, always use initialization instead of assignment
Rule 42	Do not compare a pointer to NULL or assign NULL to a pointer; use 0 instead
Rule 43	Never use explicit type conversions (casts)
Rule 44	Do not write code which depends on functions that use implicit type conversions
Rule 45	Never convert pointers to objects of a derived class to pointers to objects of a virtual base class
Rule 46	Never convert a **const** to a non-**const**
Rule 47	The code following a **case** label must always be terminated by a **break** statement
Rule 48	**switch** statement must always contain a **default** branch which handles unexpected cases
Rule 49	Never use **goto**
Rule 50	Do not use *malloc*(), *realloc*(), or *free*()
Rule 51	Always provide empty brackets **[]** for **delete** when deallocating arrays

Table 2-3 C++ Coding Rules

Rec.	Description
Rec. 1	Optimize code only if you know that you have a performance problem. Think twice before you begin
Rec. 2	If you use a C++ compiler that is based on Cfront, always compile with the **+w** flag set to eliminate as many warnings as possible
Rec. 3	An include file should not contain more than one class definition
Rec. 4	Divide up the definitions of member functions or functions into as many files as possible
Rec. 5	Place machine-dependent code in a special file so that it may be easily located when porting code from one machine to another
Rec. 6	Always give a file a name that is unique in as large a context as possible
Rec. 7	An include file for a class should have a file name of the form *class name+extension*. Use uppercase and lowercase letters in the same way as in the source code
Rec. 8	Write some descriptive comments before every function
Rec. 9	Use // for comments
Rec. 10	Use the directive **#include** "*filename.H*" for user-prepared include files
Rec. 11	Use the directive **#include** <*filename.h*> for include files from libraries
Rec. 12	Every implementation file should declare a local constant string that describes the file so that a UNIX command can be used to obtain information on the file revision
Rec. 13	Never include other files in an "*.icc*" file
Rec. 14	Do not use typenames that differ only by the use of uppercase and lowercase letters
Rec. 15	Names should not include abbreviations that are not generally accepted
Rec. 16	A variable with a large scope should have a long name
Rec. 17	Choose variable names that suggest the usage
Rec. 18	Write code in a way that makes it easy to change the prefix for global identifiers
Rec. 19	Encapsulate global variables and constants, enumerated types, and typedefs in a class
Rec. 20	Always provide the return type of a function explicitly
Rec. 21	When declaring functions the leading parenthesis and the first argument (if any) are to be written on the same line as the function name. If space permits, other arguments and the closing parenthesis may also be written on the same line as the function name. Otherwise, each additional argument is to be written on a separate line (with the closing parenthesis directly after the last argument)
Rec. 22	In a function definition, the return type of the function should be written on a separate line directly above the function name
Rec. 23	Always write the left parenthesis directly after a function name
Rec. 24	Braces **{}** which enclose a block are to be placed in the same column, on separate lines directly before and after the block
Rec. 25	The flow control primitives **if**, **else**, **while**, **for**, and **do** should be followed by a block, even if it is an empty block
Rec. 26	The dereference operator ***** and the address-of operator **&** should be directly connected with the type names in declarations and definitions
Rec. 27	Do not use spaces around '**.**' or '**->**' nor between unary operators and operands
Rec. 28	Use the c++ mode in GNU Emacs to format code
Rec. 29	Access functions are to be inline
Rec. 30	Forwarding functions are to be inline
Rec. 31	Constructors and destructors must not be inline

Table 2-4 C++ Coding Recommendations

Rec.	Description
Rec. 32	Friends of a class should be used to provide additional functions that are best kept outside of the class
Rec. 33	Avoid the use of global objects in constructors and destructors
Rec. 34	An assignment operator ought to return a **const** reference to the assigning object
Rec. 35	Use operator overloading sparingly and in a uniform manner
Rec. 36	When two operators are opposites such as == and **!=**, it is appropriate to define both
Rec. 37	Avoid inheritance for parts-of relations
Rec. 38	Give derived classes access to class type member data by declaring protected access functions
Rec. 39	Do not attempt to create an instance of a class template using a type that does not define the member functions which the class template, according to its documentation, requires
Rec. 40	Take care to avoid multiple definition of overloaded functions in conjunction with the instantiation of a class template
Rec. 41	Avoid functions with many arguments
Rec. 42	If a function stores a pointer to an object which is accessed via an argument let the argument have the type pointer. Use reference arguments in other cases
Rec. 43	Use constant references **const &** instead of call-by-value unless using a pre-defined data type or a pointer
Rec. 44	When overloading functions, all variations should have the same semantics (be used for the same purpose)
Rec. 45	Use **inline** functions when they are really needed
Rec. 46	Minimize the number of temporary objects that are created as return values from functions or as arguments to functions
Rec. 47	Avoid long and complex functions
Rec. 48	Pointers to pointers should whenever possible be avoided
Rec. 49	Use a **typedef** to simplify program syntax when declaring function pointers
Rec. 50	The choice of loop construct for **while** or **do**…**while** should depend on the specific use of the loop
Rec. 51	Always use **unsigned** for variables which cannot reasonably have negative values
Rec. 52	Always use inclusive lower limits and exclusive upper limits
Rec. 53	Avoid the use of **continue**
Rec. 54	Use **break** to exit a loop if this avoids the use of flags
Rec. 55	Do not write logical expressions of the type **if** (*test*) or **if** (!*test*) when *test* is a pointer
Rec. 56	Use parentheses to clarify the order of evaluation for operators in expressions
Rec. 57	Avoid global data if at all possible
Rec. 58	Do not allocate memory and expect that someone else will deallocate it later
Rec. 59	Always assign a new value to a pointer that points to deallocated memory
Rec. 60	Make sure that fault handling is done so that the transfer to exception handling (when this is available in C++) may be easily made
Rec. 61	Check the fault codes which may be received from library functions even if these functions seem OK

Table 2-4 C++ Coding Recommendations

Port. Rec.	Description
Port. Rec. 1	Avoid the direct use of pre-defined data types in declarations
Port. Rec. 2	Do not assume that an **int** and a **long** have the same size
Port. Rec. 3	Do not assume that an **in**t is 32 bits long (it may be only 16 bits long)
Port. Rec. 4	Do not assume that a **char** is signed or unsigned
Port. Rec. 5	Always set **char** to **unsigned** if 8-bit ASCII is used
Port. Rec. 6	Be careful not to make type conversions from a *shorter* type to a *longer* one
Port. Rec. 7	Do not assume that pointers and integers have the same size
Port. Rec. 8	Use explicit type conversions for arithmetic using signed and unsigned values
Port. Rec. 9	Do not assume that you know how an instance of a data type is represented in memory
Port. Rec. 10	Do not assume that **long**s, **float**s, **double**s or **long double**s may begin at arbitrary addresses
Port. Rec. 11	Do not depend on underflow or overflow functioning in any special way
Port. Rec. 12	Do not assume that the operands in an expression are evaluated in a definite order
Port. Rec. 13	Do not assume that you know how the invocation mechanism for a function is implemented
Port. Rec. 14	Do not assume that an object is initialized in any special order in constructors
Port. Rec. 15	Do not assume that static objects are initialized in any special order
Port. Rec. 16	Do not write code which is dependent on the lifetime of a temporary object
Port. Rec. 17	Avoid using shift operations instead of arithmetic operations
Port. Rec. 18	Avoid pointer arithmetic

Table 2-5 C++ Coding Portability Recommendations

2.5 Software Development Tools

The following software development tools and packages are used.

- Sun WorkShop Visual will be used to develop the graphical user interface (the bundled GUI builder is based on XDesigner).
- Sun Visual Workshop tools will be used for compilation and debugging.
- Rogue Wave Tools.h++ will be used wherever possible to provide standard re-usable classes.
- RogueWave Maths.h++ and LApack.h++ will be used to provide matrix classes for the navigation procedure.
- Proj will be used to provide general image projection functions.
- Xpm will be used for handing the icons of the graphical user interface.
- IDL will be used for testing.
- XV will be used to provide GIF image handling functions and for testing.
- RCS will be used for configuration control purposes.

A full description of tools is given in the Software Transfer Document [11].

3 PHYSICAL DESIGN

3.1 Introduction

This section describes how SeaShark is divided into physical design elements and how those elements communicate with each other.

3.2 The Process Model

The physical design of SeaShark is shown in the process model of Figure 3-1.

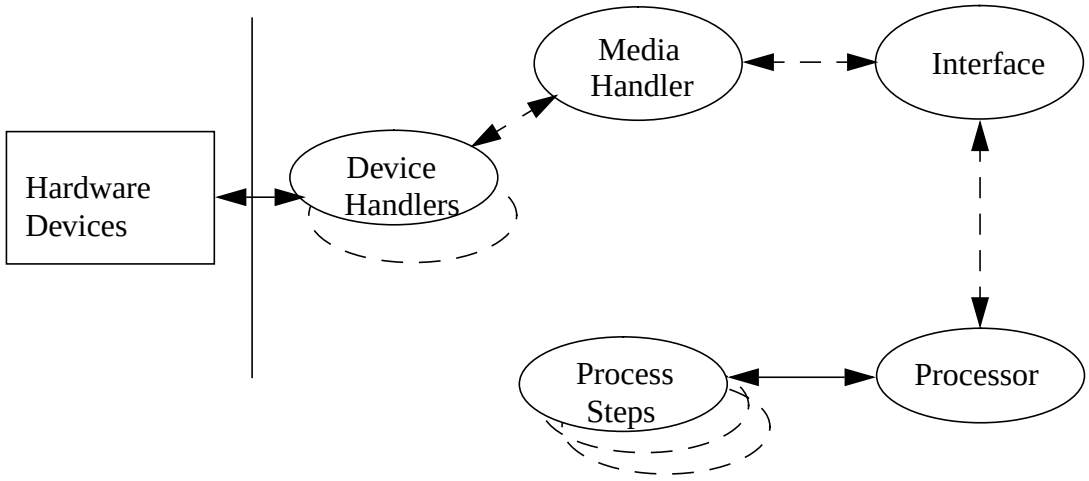


Figure 3-1 Process Model

In Figure 3-1, an ellipse represents a process and a line between two ellipses represents a communication path between two processes.

SeaShark contains the following processes:

- *User Interface* provides the graphical user interface. It is responsible for the following processing:
  - – displaying the windows of the interface to the operator;
  - – receiving operator input through the windows;
  - – sending processing request messages to the Processor;
  - – sending device access messages to the Media Handler;
  - – receiving asynchronous status messages returned by the Processor;
  - – receiving asynchronous status messages returned by the Media Handler;
  - – carrying out some processing tasks without recourse to the Processor;
  - – controlling the flow of processing through the system.
- *Processor* carries out the main processing steps. It is responsible for:
  - – receiving and parsing request messages from the User Interface;
  - – initiating the appropriate process step, with the correct arguments,

– monitoring the progress of the processing step by reading log files which the process generates;

– coordinating the sequential execution of several processing steps;

– informing the User Interface of the success or failure of the processing;

– cleaning up after any failed processing.

- *Process Steps* are executables which each carry out a main processing function. They can be initiated by the Processor or from the command line. Each executable can selectively use the parameters passed to it. All Process Steps must write a log file in the standard format.
- *Media Handler* allows access to a peripheral i/o device. It is responsible for:

  – accepting device control requests (mount, unmount etc.) from the User Interface;

  – accepting device access requests (reading, write etc) from the User Interface;

  – passing requests for sequential or very slow devices (tape) to the appropriate Device Handlers.
- *Device Handlers* communicate directly with peripheral devices which do not have their own file system and therefore cannot be mounted and treated as a normal disk. One Device Handler is spawned for each device on the system. Device Handlers cope with writing multiple files, thus eliminating the need for excessive communication during a read or write of one product.

3.3 Inter-Process Communication

Processes communicate with each other in order to send and receive information. In Figure 3-1 different line styles are used to distinguish different means of communication:

- File System Communication is represented by solid directed lines. With File System Communication one process writes information into a disc file and the information is subsequently read by another process. This mechanism is used for communication between the Process Steps and for communication between the Processor and Process Steps;
- Socket Communication is represented by dotted directed lines. Socket Communication is a Unix-specific mechanism which allows messages to be sent between different processes, either on the same computer or on different computers. It is ideally suited for the sending of small quantities of data;
- System Call Communication isn't represented in the diagram, but uses the Unix-specific *system* function which allows the initiation of a program as a separate executable. The mechanism is used by the Processor to initiate a Process Step.

3.4 Inter-Process Messages

All inter-process messages are initiated from within SeaShark which creates tokens that are transmitted to other processes. The receiving process will then return to SeaShark either a copy of the received token or a TX_ERROR token.

The messages exchanged between SeaShark and other processes are shown in Table 3-1.

Message Type	Description	Action Process
TX_MESSAGE	Status request token	Exabyte
TX_READY	Ready token	Exabyte Processor
TX_QUIT	Exit request token	
TX_STATUS	Status request token	Exabyte
TX_DIR_ENTRY	Reserved	
TX_FORMAT	Format request/acknowledgement token	Exabyte
TX_READ	Read archive product request/acknowledgement token	Exabyte
TX_WRITE	Write archive product request/acknowledgement token	Exabyte
TX_DIST	Write distribution product request/acknowledgement token	Exabyte
TX_COMMAND	Status request token	Exabyte
TX_EJECT	Eject request/acknowledgement token	Exabyte
TX_DIR	Directory request/acknowledgement token	Exabyte
TX_REWIND	Rewind tape request/acknowledgement token	Exabyte
TX_FORWARD_FILE	Fast forward tape by one file request/acknowledgement token	Exabyte
TX_BACKWARD_FILE	rewind by one file request/acknowledgement token	Exabyte
TX_WRITE_EOF	Write end of file marker request/acknowledgement token	Exabyte
TX_END_OF_MEDIA	Move to end of tape request/acknowledgement token	Exabyte
TX_MOUNT	Mount optical disk request/acknowledgement token	
TX_UNMOUNT	UnMount optical disk request/acknowledgement token	
TX_INITVOL	Reserved	
TX_FIND	Reserved	
TX_RECOVER	Reserved	
TX_MKDIR	Reserved	
TX_CD	Reserved	
TX_CP	Reserved	
TX_DU	Reserved	
TX_DF	Reserved	
TX_CHMOD	Reserved	
TX_CHGRP	Reserved	
TX_CHOWN	Reserved	
TX_TURN_PLATTER	Reserved	
TX_BACK	Reserved	
TX_IMPORT	Import product request/acknowledgement token	Processor
TX_NAVIGATE	Navigate product request/acknowledgement token	Processor

Table 3-1 Inter-Process Messages

Message Type	Description	Action Process
TX_COAST_LINE_ADJUST	Coastline adjust product request/acknowledgement token	Processor
TX_LEVEL1	Level1 request/acknowledgement token	Processor
TX_FDP	FDP request/acknowledgement token	Processor
TX_LEVEL2	Level2 request/acknowledgement token	Processor
TX_LEVEL1DISTRIBUTE	Level1 distribution product request/acknowledgement token	Processor

Table 3-1 Inter-Process Messages

A standard format is used for the messages and this is shown in Table 3-2.

Field Name	Description
_tx_command	Message type
_command_arguments	Command contents
_error_code	Error code
_error_status	Error string
_return_address	Return address
_product_id	Product id
_product_file_list	List of files in product directory
_product_directory	Location of product directory
_sensor_info	Sensor type
_device_name	Device name
_dest_device_type	Destination device type
_media_id	Media id
_sub_order_id	Sub order id

Table 3-2 Inter-Process Message Format

Messages of different type contain arguments which are appropriate for the function.

3.5 Archive Processing Chain

The SeaShark processing is designed as a number of steps which are executed in sequence, thus forming a processing chain. In this section the different steps in the processing of a raw HRPT image into a full SeaShark level 1 archive product are detailed. Each step has been implement as a standalone program which is called in the correct order by the main SeaShark program. Having each processing stage as separate executable allows any step to be repeated by the operator simply by running the program on the command line. It also allows ESRIN to easily replace any step with a newer, improved version.

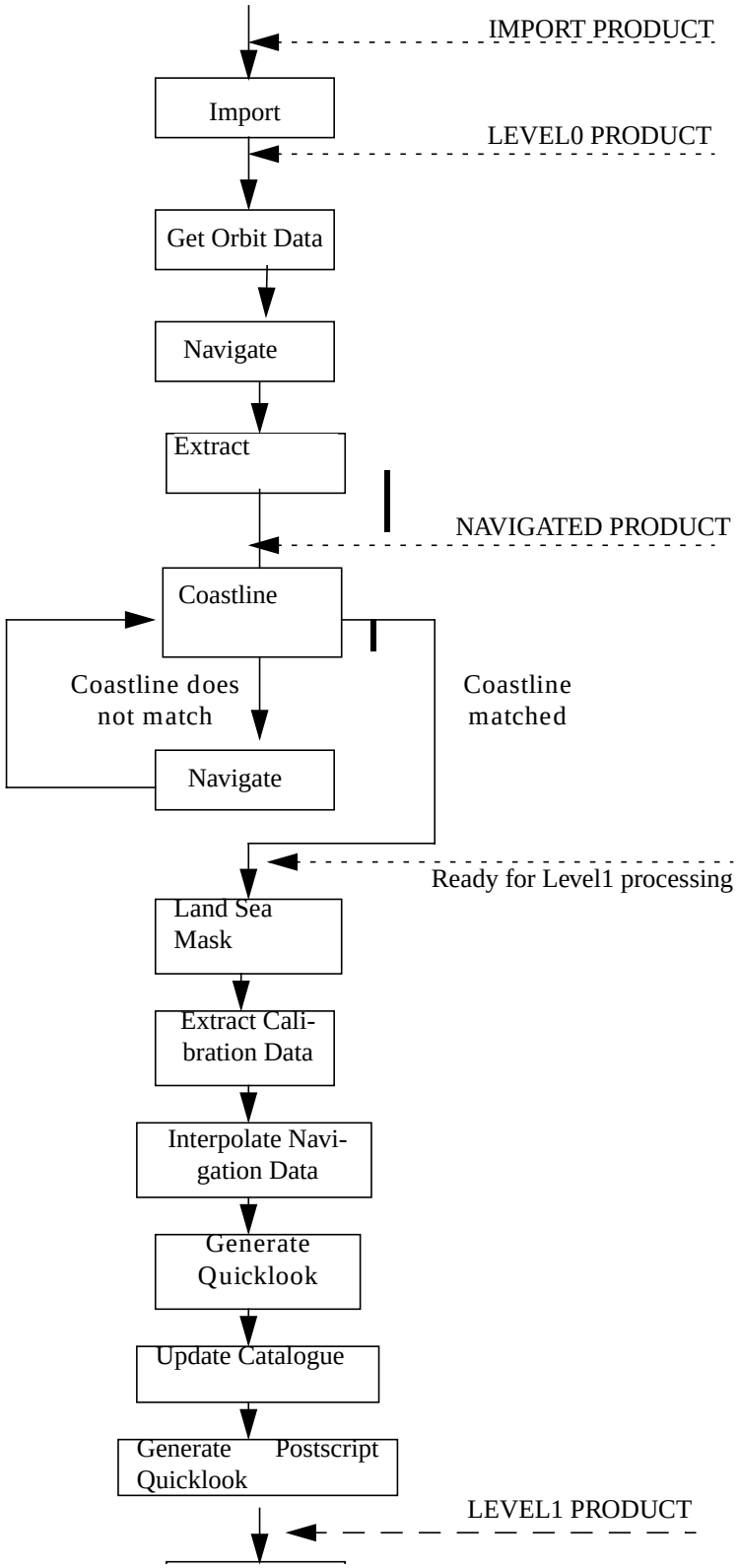


Figure 3-2 Archive processing chain

Figure 3-2 describes the execution sequence of the steps. Table 3-1 describes the steps in the processing chain. See Section 6 for a complete description.

Processing Step	Description
Import	Automatically recognises new passes of AVHRR or SeaWiFS HRPT data, checks their quality and reformats them to Level 0. The program *Import_AVHRR_Product* or *Import_SeaWiFS_Product* is used.
Get Orbit Data	Locates the most up-to-date orbit data, in the form of a tbus message, for use in the navigation. The program *Get_Orbit_Data* is used.
Navigate	Calculates the geographical location, sun angles and satellite angles for a grid of pixels in an imported image and stores them in a separate file. The programs *Navigate_AVHRR*, *Navigate_SeaWiFS_GPS* and *Navigate_SeaWiFS_TLE* are used.
Extract coastline	Extracts, from the DCW, the co-ordinates of all coastline segments within the area covered by the image and stores them in a separate file. The program *Extract_Coastline* is used.
Coastline matching	Allows the operator to overlay the coastline on a displayed image and to move the coastline until it best matches the image. The offsets needed to get a good match are written to a catalogue. The programs *Set_Coastline_Offset* and *Retransform_Coastline* are used.
Renavigate	Repeats the above NAVIGATE step taking into account the coastline offsets.
Land Sea Mask	Adds Land Sea Mask data to the image. The program *Create_Land_Sea_Mask* is used.
Extract Calibration data	Extracts the calibration information from a Level1 image. The program *Extract_Calibration_Data* is used.
Interpolate Navigation data	Interpolates the navigation data in the given file so that it has a grid line spacing exactly equal to 1. The program *Interpolate_Navigation_Data* is used.
Generate Quicklook	Generates a quicklook image from a navigated Level 1 product. The program *Generate_AVHRR_QuickLook* or *Generate_SeaWiFS_Quicklook* is used.
Update Catalogue	The program *Update_AVHRR_CatEntry* or *Update_SeaWiFS_CatEntry* is used.
Postscript Quicklook	Converts the quicklook into a printable PostScript version with added information from the catalogue. The program *Generate_Postscript_QuickLook* is used.

Table 3-3 Steps in the Archive processing chain

3.6 Distribution processing Chain

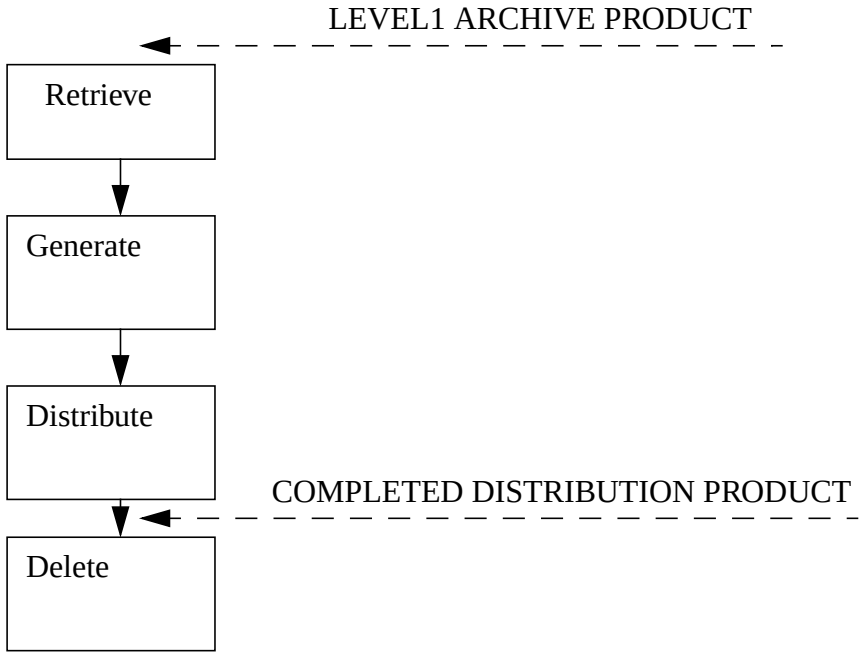


Figure 3-3 Distribution processing chain

Processing Step	Description
Retrieve	Located the necessary archive product. The programs SeaShark and Exabyte are used.
Generate	Creates the files needed for a distribution product.
Distribute	Copies the distribution product files onto archive tape. The program Exabyte is used.
Delete	Deletes the distribution product files from disk.

Table 3-4 Steps in Distribution processing chain

3.6.1 Control of the Processing Chain

SeaShark must maintain visibility and control of the processing chain so that:

- the available products are known to the operator;
- the state of any product is known to the operator;
- it is possible to recover from failed processing.

The necessary control is achieved by a combination of:

- **Directory Structures**. SeaShark maintains a directory associated with each of the Steps, into which are placed those data sets that have successfully undergone processing. As data sets are processed successfully they are moved from one directory to another. When processing is unsuccessful, SeaShark retains the input data sets and deletes any half-created output data sets, to ensure that the system remains in the pre-processing state.

- **File Naming Conventions**.
- **Log Files**. Each program outputs a log file which indicate the success or failure of the processing. By reading the log files SeaShark can determine the outcome of the processing and take appropriate action, for example it can identify products which are in an incomplete state and reset them. It can cancel later processing steps.

File System Communication is the means by which programs exchange information with each other. Most programs in the processing chain write data files which are read by a later step in the chain.

In addition to the directories described, all files related to the same product are stored in a sub-directory named with the product id. In order to distinguish different files there is a set of file naming conventions. The directory and file naming conventions described above make it possible to detect inconsistencies in the state of the system.

The control mechanisms are simple and are easily managed by the operator. In the event of serious system problems it is possible to recover by examining the contents of the directories and resetting to a known state by copying or deleting appropriate files. Automatic control by the system is the normal state of affairs, whilst manual intervention is expected to be an uncommon event.

3.7 Directory Structure

SeaShark uses a hierarchy of directories in which it stores different types of information. The hierarchy is designed to ensure that:

- related data types are kept together;
- different data types are kept apart;
- access to data is efficient.

Since SeaShark uses a wide variety of different data types, a directory hierarchy of several levels is employed. For clarity, this is reflected in the description below. First the top level of the hierarchy is described, then lower levels are described separately. The descriptions are of the standard SeaShark system, as provided on the installation tape. It should be noted, however, that the directory structure is configurable; it is possible, by editing configuration files, to change the structure to reflect particular circumstances at an acquisition station. SeaShark finds its home directory from the environment variable SEASHARKHOME and the primary configuration file from the environment variable SEASHARKCONFIGFILE.

A full description of SeaShark directory and file naming conventions appears in the Software User Manual [10].

3.7.1 Top Level Directory Structure

At the top level SeaShark is divided into a number of directories, as illustrated in Figure 3-4.

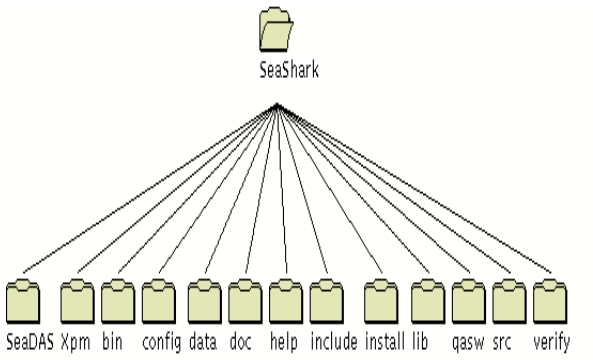


Figure 3-4 Top Level Directory Structure

The contents of the directories are described in Table 3-5.

Directory	Content
OceanColourF77	SeaWiFS Level 2 Fortran code
PROJ.4	PROJ.4 source code (cartographic projections)
SeaDAS	SeaDAS source code (HDF and SeaWiFS calibration)
Xpm	Xpm code (X window pixmap library)
bin	SeaShark executables
config	configuration files
data	data files used by or generated by SeaShark
doc	Documentation
help	help text files for the GUI, one file per window
include	header files used in software development
install	Install files
lib	library files used in software development
src	source code files used in software development
verify	Data used for verifying import was successful

Table 3-5 SeaShark Directory Content

3.7.2 Structure of the *config* Directory

The config directory contains all the configuration files, including the X-resources database, used by SeaShark. A number of configuration files are used to divide the configuration data into functionally related areas. Under the config directory there is one sub-directory, *sensors*, in which configuration data related to a given sensor is stored. There is a generic file, *Sensor.cfg*, which contains information applicable to all sensors, and a file for each sensor which contains parameters describing the performance of that sensor, information which is an important input to the processing algorithms.

3.7.3 Structure of the *data* Directory

SeaShark generates and uses data sets of many different types, all of which are stored in the data directory. Because of the varied nature of the data sets, the data directory is divided into a number of sub-directories, largely based on data type. The top level division of the data directory is shown in Figure 3-5.

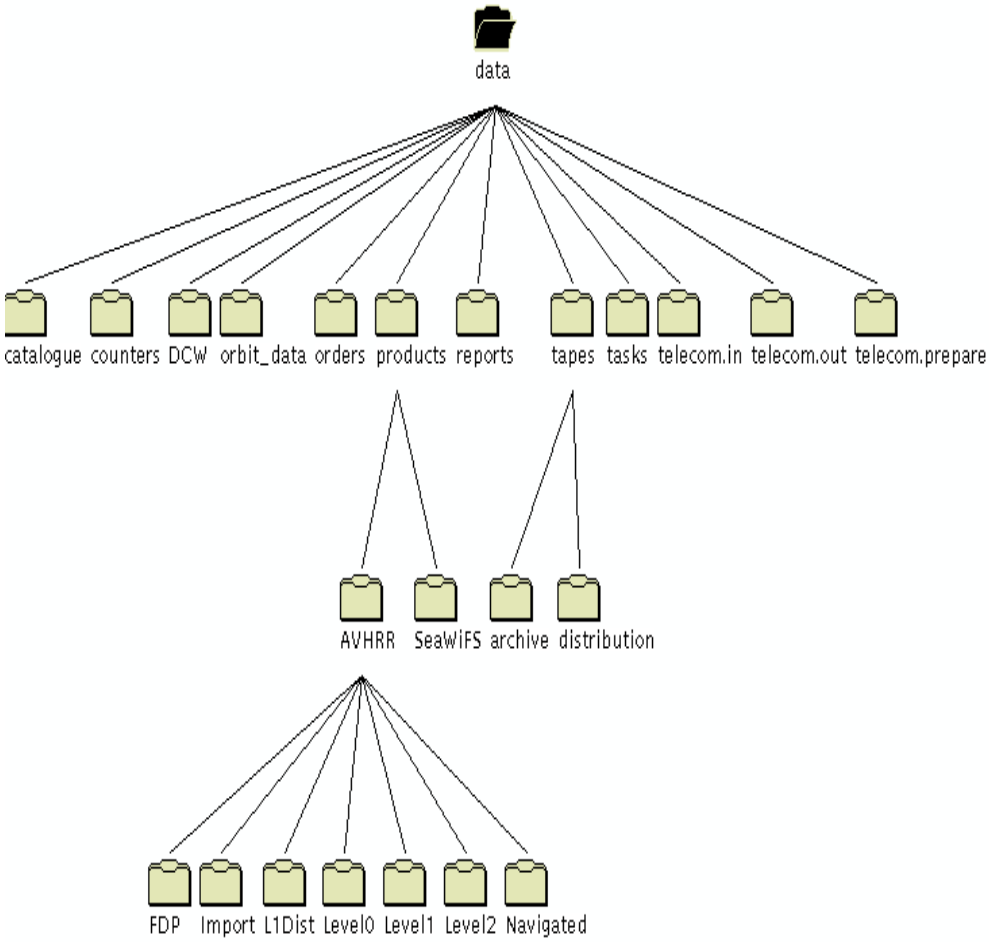


Figure 3-5 Structure of the *data* Directory

The contents of the directories are described in Table 3-6.

Directory	Content
catalogue	SeaShark keeps a database, called the catalogue, which holds important details of each generated product. There is an entry in the catalogue for each product. The catalogue entries are held as separate files which are stored in a hierarchy of sub-directories (see below for more details).
counters	SeaShark keeps an on going set of counter files for use in numbering orders and reports.
DCW	Data for the Digital Chart of the World.
orbit_data	SeaShark keeps a database of orbit data describing the position of the satellite at a given time. The information is needed for the data processing. Orbit data exists as a number of files and these which are kept in a number of sub-directories (see below for more details).
orders	SeaShark keeps copies of all ESA product orders and their processing states here.
products	SeaShark's main task is to generate products. The generated products are stored under this directory. A number of sub-directories are used to distinguish products from different sensors and products at different stages of processing.
reports	SeaShark regularly generates a number of reports, detailing the processing activities, for transmission to the central ESRIN site. The reports are stored here internally.
tapes	SeaShark writes a index file for all distribution and archive tapes.
tasks	SeaShark monitors the processing of products and their current state. Information relating to this monitoring function is stored in this directory.
telecom.in	SeaShark exchanges information with several external systems by file transfer over a network. Files to be received from an external system are placed in this directory from where they can be read by SeaShark.
telecom.out	SeaShark exchanges information with several external systems by file transfer over a network. Files to be sent to an external system are placed in this directory.
telecom.prepare	SeaShark exchanges information with several external systems by file transfer over a network. Files can be prepared in this directory

Table 3-6 Content of the *data* Directory top level

3.7.3.1 Structure of the *catalogue* Directory

The catalogue directory is divided into sub-directories first by sensor, then by year and finally by month, so that all catalogue entries from a given sensor which relate to the same year and month are stored together. Each catalogue entry is stored in a separate file.

3.7.3.2 Structure of the *products* Directory

SeaShark generates products using the data received from two different sensors:

- the SeaWiFS sensor on-board the SeaStar satellite;
- the AVHRR sensor on-board the NOAA series of satellites.

The products from each sensor are kept separate by dividing the *products* directory into AVHRR and SeaWiFS sub-directories. For both sensors, SeaShark products are generated by a processing chain. For each step in the chain, SeaShark maintains a directory into which are placed all products that have undergone that processing step. As the steps of the chain are executed the product is moved into the appropriate directory. The directories used by SeaShark to store products as they progress through the processing chain are listed in Table 3-7.

Directory	Content
Import	Raw HRPT, Level 0 or Level 1 data sets.
Level0	Products which have been imported, quality checked and formatted to Level 0.
Navigated	Products which have been navigated.
Level1	Products which have been processed to level 1 archive format.
FDP	Products which are in fast delivery format.
L1Dist	Products which are in level 1 distribution format.
Level2	products which are in level 2 distribution format.

Table 3-7 Content of the *data* Directory

A product starts out in the Import directory. When it has been imported and quality checked it is moved into the Level0 directory. From there it undergoes navigation and is moved into the Navigated directory and so on. Refer to Figure 3-2.

The directory structure of Table 3-7 is not quite complete. Within each of the directories of Table 3-7 the files from each product are stored in a sub-directory labelled with the Product Id.

3.7.3.3 Structure of the *orbit_data* Directory

There are two orbit_data types:

- TBUS messages;
- TLE (Two Line Element) sets.

The *orbit_data* directory is divided into sub-directories first by orbit_data type (TBUS & TLE), then by year and finally by month, so that all orbit data messages of a given type which relate to the same year and month are stored together. Each orbit_data message is stored in a separate file.

3.7.3.4 Structure of the *telecom.in* Directory

The telecom directories are used for the electronic transfer of data between an acquisition station and the central ESRIN site. SeaShark exchanges information with several external systems by file transfer over a network. Files to be received from an external system are placed in the *telecom_in* directory from where they can be read by SeaShark. There are two sub-directories: *orders,* into which new orders from the central ESRIN site are placed, and tmp, into which orders can be placed temporarily.

3.7.3.5 Structure of the *telecom.out* Directory

The telecom directories are used for the electronic transfer of data between an acquisition station and the central ESRIN site. SeaShark exchanges information with several external systems by file transfer over a network. Files to be sent to an external system are placed in the *telecom.out* directory. The directory is divided into a number of sub-directories for different data types as shown in Figure 3-6.

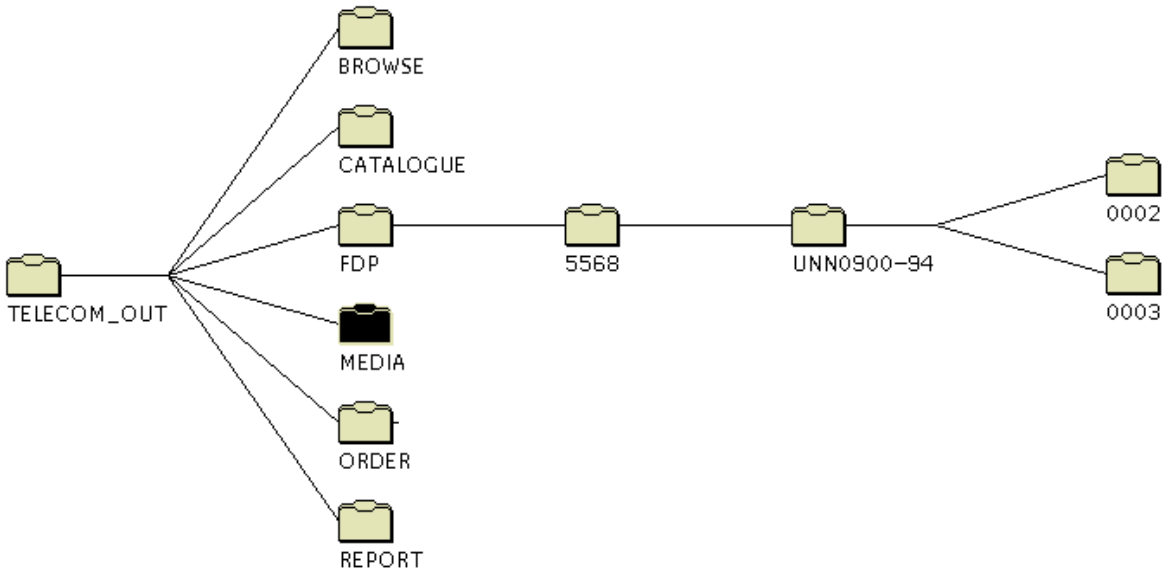


Figure 3-6 Structure of the *telecom.out* Directory

The directory “telecom.out” contains a number of directories into which different types of data are placed ready for transmission to ESRIN. The type of data stored in each directory is self explanatory. Note that the directories FDP and ORDER are further divided by USER_ID, ORDER_ID and SUB_ORDER_ID.

3.8 File Naming Conventions

The Software User Manual [10] defines the naming conventions and formats of files used by SeaShark. Some of the file formats are defined externally to SeaShark whilst some are defined within the SeaShark project. For the former a reference is made to the relevant documentation; for the latter a reference is made to the appropriate section of this document.

3.9 System Start-up

SeaShark is started by executing the User Interface process. The User Interface reads the configuration file to find the location of the processes to start and then spawns each one, as a child process. The User Interface then attempts to connect to each child by a standard socket. If the socket is still active a socket reuse facility is tried to initiate the connection. Once each connection has been made the User Interface allows operator interaction.

Spawning a process is done by the Unix-specific *fork()* and *execv()* commands. If the processes cannot be spawned or communications cannot be made, the User Interface cleans up and exits.

A media handler process (one for each different type of device) controls any device access by queuing requests and allowing the interface to continue without having to process a continual stream of messages from the device handlers.

The processor process communicates with the interface to get instructions as to the processing steps required. As each request arrives the processor spawns independent executables to perform the processing. This allows easy maintenance (as each executable can be changed independently of SeaShark) and command line access to the processing steps.

Each process step that the processor spawns runs to completion without giving control back to the processor. On completion of each process step a log file is written detailing its results. Every feasible parameter is passed on the command line to these processing steps. No other means of communication exists between these processes to make development of new processing steps a simple exercise.

3.10 System Close Down

When the User Interface is closed, every open socket connection is sent a message to tell it to close down. This allows every process to finish its current work and exit in a graceful manner.

3.11 Controlled Termination of Processes

Under certain circumstances an operator may wish to terminate a process before its natural completion. SeaShark handles this situation carefully to prevent the operator having to restart SeaShark. It ensures that the integrity of queues and process status flags are kept. System resources such as file descriptors and any communication resources are relinquished correctly to avoid problems of free resources later.

Our aim is to separate the processing steps from the main processor process to allow it to be terminated. However, we do not want to make it difficult to return the status each processing step.

A solution to this problem is to trap an interrupt which can be generated by the unix system command ‘kill’. The kill command would be executed with the process id of the processing step. This would mean that any new processes added to the system would have to trap an interrupt, clean up their system resources, write the log file to indicate what happened and exit.

A second and probably cleaner solution is to kill the child process and monitor the return status from the processor. Spawn will return an interrupted status and then it is up to the processor process to clean up after the processing step.

If we used the first method the child process would exit in the normal way and the system could handle the termination in the same way as a processing failure. However, the second method is far simpler to implement and if the processing step is killed by the system an operator the same recovery procedure would be used. Also the second method allows processing steps more freedom and does not impose restrictions on their implementation.

3.12 Error Handling

As an operational system, SeaShark provides facilities for automatic error checking and recovery. These facilities make it easy, in the event of many system problems, for the operator to restart the processing. There are, inevitably, some situations in which automatic recovery is not possible and which therefore need operator intervention to restore system integrity. This will be done using some unix commands and not via the SeaShark interface. For this reason the underlying structure of the software, for example the directory structure, has been kept simple. The operator is assumed to be capable of acting on messages issued by the system. This usually involves checking the directories for incomplete or missing process files, deleting appropriate ones and renaming others to maintain system integrity and then rerunning the processing from an appropriate step.

This section describes a number of possible errors and the action needed to recover from them:

- Catastrophic system crash, such as disc failure, unrelated to the SeaShark software. If this happens then the site system administrator will have to fix the fault and maybe place the data back on to the system as it was at the last system backup. When access is gained to the system the SeaShark interface should be run. Any log files or processing files will be removed and the system returned to a state where all processing can continue. At times the system may find it has reached a state where there are two products of the same name on the system. SeaShark will detect this and query the operator to remove the product.
- Killing of processes. If the interface process is killed then each of the sub processes will exit because each socket will detect the fact that it is not possible to communicate to the interface and the process will finish what it is doing and exit. On restarting SeaShark the system will read the last status of the system and restart; this may mean that the last few operations may be lost. If any of the other processes die the system will complain when any requests are sent to the dead process. It is up to the operator to exit SeaShark and restart it. It will be possible to continue with remaining processes.

3.13 Tasks

3.13.1 Description

The task is an important concept within the SeaShark design. A task can be defined as an item of work which SeaShark must perform. A task has an independent identity, separate from the product or order from which it is derived. Two types of task, a Product Task and an Order Task, are recognised by the system.

- A *Product Task* concerns the generation of Level 1 products from Level 0 data. This is routine processing which is carried out on every HRPT data set entering the system. For such products a task is automatically generated.
- An *Order Task* concerns the generation of products, such as Fast Delivery products, requested in user orders. Order Tasks are automatically generated when new orders are entered into the system, either when they are received in an incoming network directory or when they are manually entered.

3.13.2 Storage

A task appears in two places within SeaShark.

- *On disc*. Disc versions of tasks are held in the Task Store, which is a directory in the data area. Each task is held in a separate file. The Task Store is split into two sub-directories called Product and Order. Tasks within the Product directory are labelled with the product ID. Tasks in the Order directory are within directories labelled with the order ID, containing tasks labelled with order and sub-order ID's concatenated. Task files store a major and minor software version number. This is used to provide compatibility between the software and task files.
- *In memory.* Memory versions of tasks are held within the User Interface, which maintains a list of all current tasks in the system. The list is used in the Task and Batch windows to allow the operator to view, select and initiate tasks. Every task in memory has a unique identifier which is generated from within the TaskPool (each task that is loaded into memory is given the next number in sequence). Task identifiers are not stored at any time and are unique to each execution of SeaShark.

Tasks are only used by the SeaShark main process. Task information required by other processes are passed via tokens.

Object stores are used for task lists and task queues. Both structures are stored each time their contents changes allowing the system to recreate itself each time it starts up. The object stores will contain only the list of subject ID's associated with them.

3.13.3 Task Pool

The TaskPool contains every task that is within SeaShark. Storage is organised by saving each task in either the product or order task directory. The interface is initialised with the full list of tasks within the system. When the system is started the Task Pool reads every task within the task store and loads each into memory. A verify process checks that each task has an associated product. If it does not, the task is removed. A check is also made that each product has an associated task. A warning message is logged if this is not the case.

The data members of the TaskPool are shown in Table 3-8. New tasks are created when products are imported or retrieved and when new orders are generated. Tasks are deleted when products and orders are deleted or removed.

Variable	Description
_avhrr_task_list	Linked list of AVHRR tasks
_seawifs_task_list	Linked list of SeaWiFS tasks
_global_task_id	Counter for updating task id
_task_type_filter _task_status_filter _scheduling_filter _process_status_filter _source_media_filter	Filters used for task list display

Table 3-8 Task Pool data structure

3.13.4 Individual Tasks

Each task has an instance of a Task class which in turn has an associated TaskForm instance. It is the TaskForm data that is written to disk.

The data members of the Task class are shown in Table 3-9, and data members of the TaskForm class are shown in Table 3-10.

Variable	Description
_task_form	TaskForm instance
_valid	Boolean to flag valid/invalid tasks
_task_id	Task id number

Table 3-9 Task data structure

Variable	Description
_dirty_bit	TRUE if structure needs to be saved, FALSE otherwise
_prepared_telecom	Indicates that files have been copied to telecom_prepare
_tmp_suffix	Suffix to use for temporary files
_sensor_info	Describes the sensor for this task (SensorInfo instance)
_schedule_state	The scheduling of the task: none, immediate or batch
_subject_type	Type of task: order, product, reference product, etc.
_subject_id	Either the product or order id.
_product_id	Either the product or reference product id.
_state	The state of the task, i.e. uninitialised, processing, etc.
_process_type	Current or next process to happen.
_type_of_product	Describes processing type: e.g. L1A, L1B, FDP, etc.
_optical	Name of optical order
_x_offset, _y_offset	Offset values used for Coastline Adjust
_last_x_offset _last_y_offset	Offset values used for the previous Coastline Adjust
_process_steps	Work that has been done on the task.
_import_type	Type of import: HRPT, Level0, Archive or Level1
_default_optical	Default string for _optical

Table 3-10 Task Form data structure

The TaskForm data members *_process_steps* and *_process_type* are used to control task processing. For an inactive task *_process_type* specifies the next step in the processing sequence. The mask *_process_steps* records each step of the processing sequence that the task has undergone or that has been selected for future processing. This parameter reflects the disposition of toggle buttons on the task form window.

The function *update_task()* is used to update the Task Pool when a task changes. The disk copy of the task is also updated if *_dirty_bit* is set.

Processing is initiated by placing the task on one of the task queues.

3.13.5 Task queues

There are two types of task queue used in SeaShark.

- *Immediate*. The next queued task will become active as soon as the current active task on this queue completes.
- *Batch*. When batch processing is activated the tasks on this queue are transferred to the associated immediate queue for processing. This type of queue acts as a holding store; tasks are not processed directly from it.

There are four queues of each type.

- *Archive*. This queue handles tasks for archiving, post-archiving deletion and retention as reference products.
- *Distribute*. This queue handles tasks for distribution and post-distribution deletion.
- *Retrieve*. This queue handles retrieval tasks.
- *Process*. This queue handles all other processing.

The data members of the TaskPool are shown in Table 3-8.

Tasks are placed on the relevant queue either by operator action or automatic detection of import products or orders. The task state is set to Waiting (Queued). On every SeaShark timer event the four immediate queues are polled. If the queue is not active, the first waiting task is serviced. When a sequence of processing steps is in progress the task is moved as necessary from one queue to another. In practice this only involves tasks in the processor queue which may be moved either to the archive queue or to the distribute queue.

Variable	Description
_task_queue	Linked list of tasks in the queue
_queue_store	File for storage of task queue store. This name is supplied by a configuration parameter (eg “process_immediate_queue”).
_loaded_ok	Boolean indicating the load status of the task queue store file.
_tmp_suffix	File name extension for temporary queue store file (default .tmp).
_seawifs_entries	Number of SeaWiFS tasks in the queue.
_avhrr_entries	Number of AVHRR tasks in the queue

Table 3-11 Task Queue Store data structure

3.13.6 Task creation

The following steps show how a new task may be created:

1) Create a new Task instance.

2) Set the task data members to the relevant values using the appropriate member functions. Typically these will include *SetScheduleState(), SetSubjectID(), SetProcessType(), SetProcessSteps(), SetSensorType()* and *SetTaskState()*.

3) Save the current global task ID (*globals->task_pool().global_task_id()*).

4) Use *globals->task_pool().next_task()* to create the new task. This will be assigned the current global task ID.

5) Check that the task did not already exist by comparing the task ID with the ID saved in 3) above.6) Use *update_task()* to save a copy of the task to disk.

Some of the member function that are used to handle tasks are shown in Table 3-12.

Function	Description
GetScheduleState	Indicates whether the task is on an immediate queue, batch queue or none.
GetTaskState	This is one of: Uninitialised, Waiting, Processing, Archiving, Retrieving, Distributing or Error.
GetProcessType	This indicates the next or current process.The type for Level2 processing is 'TypeLevel2', and the specific processing is indicated by GetTypeOfProduct.
GetTypeOfProduct	This is one of: L1Arc, L1ADist, L1BDist, L2ADist, L2BDist, FDPDist, L2CDist. There are also Boolean functions available for individual product types; eg IsL1A, IsFDP.
GetTypeOfProduct-String	There are a number of functions available that return task parameters as text strings. These are mainly used for display purposes.
GetProcessSteps	This is closely linked to GetTypeOfProduct. The process_steps mask consists of all the process_type values for a task OR'd together.
GetName	This returns a string containing the product, or order, ID.
getProductDirectory	This returns where the product data required for processing the next step is stored on the system.
getCurrentProductDirectory	This returns where the product files are currently stored on the system, or an error if the product files have not yet been created.
next_task	Create a new task with the next global task id.
update_task	Update a task in memory and on disk.
get_task	Searches for a task within the task pool and returns it if found.
remove_task	Searches for a task within the task pool and removes it if found.
product_on_disk	This routine searches for products used by the task. Return values indicate whether the product is on disk, and if the product is referenced by an order.

Table 3-12 Selected task member functions

3.13.7 Task example

Consider a task which is to undergo Navigation processing. When the task has been selected from the task list, the task form window is built using *AppearTaskForm()*. The toggle buttons are set using the *_process_steps* and *_process_type* values. In this example no toggle buttons are shown as being depressed.

Now press the Navigation button in the task form window. The function *ProcessStepChanged()* checks that the button configuration is valid before setting the button display and tests the *_process_type* bit in the *_process_steps* mask to confirm that the next process to run matches the button selection. A confirm window is then displayed to allow processing to begin. When Immediate is pressed the task's schedule state is set to Immediate, and the task state to Waiting (i.e. Queued). Using *update_task()*, the task is updated in memory and on disk. Finally the task is placed on the process immediate queue.

On the next SeaShark timer event the queue handler function *service()* will poll the process immediate queue. If the navigation task is the next task that is in the Waiting state, it will be processed by *do_service()*. This function builds a token and passes it to *processor_handler()*. It also sets the task state to Processing and updates the task in memory and on disk.

In *processor_handler()*, *SendToken()* sends the token to the *processor* process; tasks are only used in the main SeaShark process.

When *processor* has completed navigation, a token is sent to the *processor_handler()* function, *RecievedToken()*. Using the product ID contained in the token, the relevant task is fetched using *get_task()*. If the navigation completed successfully, the task state is set to Uninitialised and *_process_type* is set to the next processing step. The next step depends on which task form toggle buttons have been pressed. If no further processing was selected, *_process_type* will be set to *TypeCoastLineAdjust*, the schedule state set to None, and the task removed from the process immediate queue. Finally the task is updated in memory and on disk.

3.14 Orders

3.14.1 Terminology

The following terminology is used:

- An *ESA Order File* is a file containing ESA Orders.
- An *ESA Order* or *Order* is a request for product generation. It is represented by a single line in the ESA Order File which defines the product to be generated in terms of reference product ID and either centre latitude/longitude or start and stop times. See [36] for more details.

3.14.2 External Interfaces

Order handling at an acquisition station uses two external interfaces:

- the import of ESA Order Files from ESRIN;
- the return of Order Status Files to ESRIN.

These interfaces are specified by the formats of the ESA Order and Order Status files, and the directory structure used for file exchange. The formats of the files are defined in [36] (standing orders are not supported), with clarification of the order status codes provided in email messages from ESRIN. The file names and directory structures are defined below.

3.14.3 Physical Design

SeaShark uses three directories to store orders:

- *an import directory*, $SEASHARKHOME/data/telecom.in/orders, into which new ESA Order Files from ESRIN are placed. This is done by an external telecommunications system and is outside the scope of SeaShark. No assumptions are made about the names of files in the import directory;
- *a store directory*, $SEASHARKHOME/data/orders/Store, into which orders are placed ready for processing. The store directory is sub-divided into directories uniquely labelled using the order code and sub-order number taken from the Order. Each subdirectory contains two files: a copy of the ESA Order File (named “Order”) and an Order Status File (named “OrderStatus”).
- *export directories*, $SEASHARKHOME/data/telecom.out/orders, into which Order Status Files are placed for transmission to ESRIN, and $SEASHARKHOME/data/telecom.out/fdp, into which FDP products are placed. The transmission is the responsibility of an external telecommunications system and is outside the scope of SeaShark. The fdp directory is subdivided into directories labelled using the following fields from the Order: *destination-*

code/order-code/suborder-number (see [36]). Within the order directory, each of the files are named using the following pattern: *AASSSSSS.EEE*, where *AA*=acquisition station, *SSSSSS*=sequence number and *EEE*=extension (“sta”).

The above pathnames can be changed by editing the configuration file. SeaShark automatically moves files from one directory to another at the appropriate time in the processing chain.

3.14.4 Errors

There are several different types of error: non-fatal errors which are reported via the shell window that SeaShark is running in, and fatal errors or warnings which are reported by the use of dialogue boxes.

The following list describes the actions which SeaShark can take when an order error occurs:

1) Reject and delete the order.
2) Reject the order and write a status file.
3) Place the order in an error state.
4) Ignore the error and use a default where appropriate.
5) Move the order to the failed order directory.
6) Write an error message to the shell.
7) Write a simple error notification message in the Main window.
8) Show an info/warning/error dialogue box.
9) Crop the image to fit the pass height.

The following table shows possible errors, the point in the processing chain at which the error is detected, and the action that SeaShark will take in each case.

Error Description	Stage Detected	Action
Invalid/missing ESA Order code	Import	5,6,7
Invalid/missing Sub-order Number	Import	5,6,7
Invalid/missing Satellite Id	Never detected	4
Invalid/missing Satellite Mission Number	Never detected	4
Invalid/missing Sensor Id	Never detected	4
Invalid/missing/unknown Product Code	Processing (FDP only)	3,6,8
Invalid/missing Centre Latitude/Longitude	Processing	3,6,8
Invalid/missing Bottom Latitude/Longitude	Never detected	4
Invalid/missing Start/Stop Date	Never detected	4
Invalid/missing Start/Stop Time	Processing	3,6,8
Invalid/missing Pass Id	Import	2,6,7

Table 3-13 Order errors

Error Description	Stage Detected	Action
Unknown Pass Id	Processing	3,6,8
Invalid/missing Order Type	Import	2,6,7
Invalid/missing Media Type	Distribution	4,6
Invalid/missing Product Type	Import	2,6,7
Invalid/missing Priority	Never detected	4
Invalid/missing Product Station	Never detected	4
Invalid/missing Destination Code	Distribution (FDP only)	3,6,8
Invalid/missing Shipping code	Never detected	4
Invalid/missing Comments (external order)	Never detected	4
Invalid/missing Comments (internal order)	Processing	3,6,8
Order already imported	Import	5,6,7
Order-by-location size > pass height	Processing	6,9
Directory created in telecom.in/orders	Import	4

Table 3-13 Order errors

3.14.5 Failed Order Directory

If an order is received which has a missing or corrupt order code and/or sub-order number, it cannot be identified, so no directory can be created for it on the system. Also, because the order cannot be identified, a status file cannot be written.

To prevent the order being deleted and lost completely, it is copied to a directory at the location specified by the *failed_order_directory* tag in the SeaShark.cfg file. Rejected orders, for which no status file may be written, are copied to this directory and named using an incrementing counter e.g. FAIL000001. A message is written to the shell when this happens, so that the error and its associated FAIL file can be matched. In the case of multi-order files, only the rejected sub-order is copied, not the whole multi-order file. If no location is specified in the SeaShark.cfg file or the specified directory does not exist, the failed order directory is not used and rejected orders are deleted (action 1, above).

It is the operator's responsibility to empty this directory when necessary. The directory is not polled.

3.14.6 Multi-Order Files

A multi-order file is an ESA Order File which contains more than one ESA Order. Each order in a multi-order file is processed individually. This prevents the whole multi-order file from being rejected whenever an error is detected in a single order.

3.15 Archive Products

3.15.1 Physical Design

Refer to Table 3-7, "Content of the data Directory," on page 23 and See "Import" on page 72.

3.15.2 Errors

The following table contain a list of some of the errors that can be generated on attempting to produce an archive product. Processing errors are also discussed in the Software User Manual [10].

Stage of processing	Error text	Description or error
any stage	Invalid sensor *<sensor code>*	The sensor used in the product is not listed in station.cfg
any stage prior to archiving	Error cannot open the input catalogue entry file	The catalogue.iuf has been deleted or made read only.
archiving	Disk full tape index not written for *<product id>*	The disk is full.
importing	Failed to read import directory	The import directory does not exist or is read only.
any stage	Unable to write Q-store file	The list of queues is unavailable
navigation	No valid GPS found: please use TLE navigation	The GPS does not exist.
any stage	Executable does not exist *<executable name>*	The executable mentioned does not exist in the $SEASHARKHOME/bin directory
navigation	Product is in an invalid state.	Import failed
import	Image read failed	the IMAGE_HRPT file does not exist or is read only.
import	Image file is invalid	The IMAGE_HRPT file is incorrectly formatted
import	Not enough memory	The disk is full
navigation	Note enough memory to access the DCW database	Memory problems
navigation	cannot access the DCW directory	The DCW directory defined in the SeaShark.cfg parameter dcw_database_directory does not exist.
any stage	Tasks are incompatible for multiple selection	The multiply selected tasks are not at the same stage of processing
navigation	cannot create land sea mask file	The product directory had been deleted or is read only
Level 1	cannot create such a large quicklook	The size of the quicklook is too large.

Table 3-14 Processing Errors

Stage of processing	Error text	Description or error
Level 1	Error in given sampling factor	The sampling factor given in the SeaShark.cfg in the parameter quicklook_<*sensor*>_sampling_factor is incorrect.
Level 1	Sampling factor must be greater than zero	The sampling factor given in the SeaShark.cfg in the parameter quicklook_<*sensor*>_sampling_factor is incorrect.

Table 3-14 Processing Errors

4 PROCESSING INTERFACE

This section defines how SeaShark executes processing tasks. Some are automatic, others require operator intervention.

4.1 Archive Processing

4.1.1 Polling The Import Directories

SeaShark makes use of timers to trigger events. On every timer expiry (default 10 seconds) the $SEASHARKHOME/data/products/*sensor*/Import/* directories (Archive, HRPT, Level0 and Level1) are checked for new directories.

If a directory exists in the HRPT directory, this new directory is searched to see if it contains an AQTIM.DAT file. If an AQTIM.DAT file exists and an IMAGE_HRPT file is also present, both files are imported into SeaShark and a Task is created which appears in the Task List window.

If a directory exists in one of the other Import subdirectories, this new directory is searched to see if it contains a catalogue.iuf file. If a catalogue.iuf file exists, various files are imported into SeaShark and a Task is created. The imported files are those required for a product processed to the level specified by the import directory name e.g. a level1 product imported via the Level0 import directory will be imported as a level0 (pre-navigated) product, and the Task created will reflect this.

4.1.2 Viewing The Status Of Products

The Task List window allows the operator to see the details of a product, to initiate its processing and monitor its progress. It allows the processing of lists of products which are at the same stage of processing (Batch processing). Each line of the list represents a product and shows the current status of that product's processing. The information shown is:

Product ID – The identifier for the product.

Level – The current processing stage for the product. The following values are used:

- Import (used while the product is being imported)
- L0 (used prior to navigation)
- L1 Arch (used after navigation)

Status – The processing activity flag for the product. The following values are used:

- - (used for archived products where no further processing is possible)
- Ready (the product is ready for further processing)
- Queued (the product has been added to the Immediate queue for processing)
- Error (something went wrong with the last processing step)
- Active (the product is undergoing processing)
- Batch (the product has been added to the Batch queue, and is awaiting the start of the next batch job)

To – The next stage of processing for the product. The following values are used:

- Import
- Navigate
- Coast line adj

- Level 1
- Delete
- - (used for archived product)

4.1.3 Counting The Products On The System

The Main window contains a count of the number of products on the system.

4.1.4 Selecting Processing Steps

A product can be progressed through the five processing steps by operator intervention. The required steps can be selected using the Processing Steps toggle buttons in the Task List window. Selecting the Process button will cause a Confirm window to appear and the selected processing steps will commence when a queue is selected.

4.1.5 Viewing The Image

A non-active product can be displayed at any stage using the Display button in the Task List window to bring up the Display window. The desired image band can be selected from the band menu and the band displayed by selecting the Display button in the Display window.

4.2 Order Processing

4.2.1 Polling The Import Directory

As mentioned earlier, SeaShark makes use of timers to trigger events. On every timer expiry (default 10 seconds) the $SEASHARKHOME/data/telecom.in/orders directory is read. When a new ESA Order File appears in the Import directory it is checked for various errors (see Table 3-13). If no problems occur, the order is copied to the $SEASHARKHOME/data/orders/Store directory and a Task appears in the Task List Window.

4.2.2 Processing

As processing of the ESA Order proceeds, the OrderStatus File is modified to reflect the processing which has taken place. When processing is complete, and the products have been written onto a distribution media or into a telecom directory, a Shipping Date and appropriate code are added to the Order Status File (See [36] for specific field details).

4.2.3 Sending Status Files

A regular check is made for orders with a complete shipping date (the time between each check is set in the Prepare Order Status timer). Such orders are moved to the export directory and renamed with the file name *SSNNNNNN*.sta (where *SS* is the Station code and *NNNNNN* is a unique counter).

4.2.4 Purging The Order Store

After completion, ESA Orders are kept on the system for a predetermined ‘retention period’ (the time is set in the Clear Order timer). A thirty day check is made to examine their Shipping Dates and copy those ESA Orders whose retention period has expired to a backup directory. It is the responsibility of the operator to manually remove them from the backup directory, if nec-

essary.

4.2.5 The Operator Interface

The operator interface provides the means for controlling the processing of orders. All control takes place using the Task List window, as for archive product processing. Selecting an order will show the processing steps completed, and those still to be performed, in the Processing Steps section of the Task List window. From here, the operator can select which steps are to be performed and execute the processing by selecting the Process button. A Confirm window will appear and processing will commence when a queue is selected.

4.2.6 Counting The Orders On The System

The Main window shows the number of Orders which are on the system, either waiting to be processed or undergoing processing. Those orders which have been processed and are still on the system, pending expiry of their retention period, are not included in the total.

4.2.7 Viewing The Status Of Orders

The Task List window allows the operator to see the details of an Order, to initiate its processing and to monitor its progress. It also allows the processing of lists of orders.

The filters at the top of the window allow the operator to view orders which satisfy the selected criteria (the display is updated automatically). Each line in the list represents an order and shows the current status of the order's processing. The information shown is:

- Product – the identifier for the reference product associated with the order.
- Order – the unique identifier for the order (ESA order code and suborder number combination.
- Level – the stage to which the order has been processed. The possible levels are:
  - - (used before retrieval and after distribution)
  - L1 Arch (used by retrieved orders)
  - *Order type* (e.g. L1B,L2A,L2B,LFD1,SFD1) (used by generated product)
- Status – the current processing state for the order. The possible states are:
  - Error – something went wrong with the last step.
  - Ready – the order is ready for the next processing stage.
  - Batch – the order is ready for the next batch job.
  - Queued – the order will undergo processing when the immediate queue empties.
  - Active – the order is undergoing processing.
- To – defines the next stage in the processing chain. The possible stages are:
  - Retrieve – ensure the reference product is on the system.
  - *Order type* Processing – generate the ordered product.
  - *Order type* Distribute – write the generated products to the distribution medium.
  - Delete – remove the generated products from the system.
- Customer – the identifier for the customer for the order.
- Media – the distribution media type identifier.

4.2.8 Initiating Order Processing

When an Order first enters the system it is in the retrieve state, in which it can be selected and

initiated. Retrieval starts the processing chain. The required steps in the chain are determined by SeaShark and the appropriate steps are checked in the Task List window. Once the Order has been initiated it proceeds automatically. The operator would not normally intervene in the processing, unless:

- operator intervention is needed to place an archive or distribution medium in the tape drive. The system uses a pop-up dialogue to prompt the operator when medium handling, for example the insertion of a tape, needs to be done;
- the operator wishes to cancel the Order. This is done from the Task List window, in which case the Order reverts to the uninitialised state and can subsequently be reinitialised.

4.2.9 Viewing Full Order Details

In the Task List window the most important details from the Order are shown. Full details can be seen by selecting the Order Form button in the Task List window which will cause the Order Form window to be displayed. This shows information as it is appears in the Order itself, including the fields which are not needed by SeaShark.

4.2.10 Entering New Orders

4.2.10.1 External Orders

For external orders the order file is placed directly into the $SEASHARKDATA/telecom.in/orders directory.

4.2.10.2 Order Form Window

In the discussion so far, orders have arrived via network and have been automatically imported into the system. In some circumstances, for example when network communication with ESRIN is not possible, it may be necessary to manually enter orders into the system. This can be done using the same order form which was described above for viewing full order details.

From the order form, an order file is created and copied into the $SEASHARKDATA/telecom.in/orders directory. This order file is then detected and used in the same way as for external orders.

An order contains a description of the product which is required and the distribution medium needed to disseminate it. Therefore, when an order arrives the process options can be set automatically within the Task List window, and the task needs no intervention apart from the initial decision between immediate or batch processing.

When an order is initiated, its requirements are first determined and tasks created for retrieval of the desired products from the archive. Each request becomes a new task and is placed within the TaskPool. The calling task will interrupt itself and wait for each of the tasks to be completed. In batch mode each of the tasks are placed on the batch queue. (It is assumed that in immediate mode the operator will be at his/her terminal controlling the process.)

When an order is distributed to tape, the tape capacity is checked. If the quota for the device (defined within the configuration file) is reached, the task is placed in an error state.

4.2.10.3 Interactive Orders

An interactive order is created using the Interactive Control window, which is displayed by

selecting an archive product from the Task List window and selecting the Process button. The Display window will also appear, if the archive product is not from an optical disk, so that the desired part of the archive product can be selected (optical products are already formatted by ESRIN and fixed at 1440 lines in length). When the image is displayed, the start and stop lines are overlaid in red and can be moved by the operator using the arrow keys in the Interactive Control window. The times shown to the left of the text boxes will be written into the order when it is generated, and the line numbering starts at zero and is inclusive i.e. if the start line shows “1” and the stop line shows “498”, the final product will contain 498 lines. When the operator is happy with the settings in the Interactive Control window, an appropriate order will be generated when a selection from the Accept menu is made. This order file is placed in the $SEASHARKHOME/data/telecom.in/orders directory and processed in the same way as any other order.

4.3 Immediate and Batch Processing

SeaShark offers two types of processing, Immediate Processing and Batch Processing. Immediate Processing refers to work items which the operator wants the system to execute at the earliest opportunity. Batch processing refers to work items which the operator wishes to make ready for execution but whose execution he wishes to defer until a later time.

All Processing is carried out by the Processor which sequentially reads items of work from a Process Queue. There is only one Processor and only one Process Queue. All work items, whether immediate or batch, are entered into the Process Queue. However, immediate work items are entered at the top of the queue and are therefore selected for processing first. If the Process Queue contains only batch items, processing only continues if the operator has turned on the batch processing option. This allows the operator to prepare work items which are queued for batch processing, which can be turned on at a suitable time, typically just before he goes home in the evening.

Since there is only one Processor, which processes one work item from the Process Queue at a time, SeaShark has no concept of concurrent processing, whereby several work items are being processed at the same time. Because of the nature of SeaShark processing, there is no significant advantage to be gained by having more than one work item being processed simultaneously by the system. This means that even ‘immediate’ work items might have to wait a short time before they are processed.

The Process and Batch queues are internally maintained lists of queued Tasks and are initialised from the Task Pool when SeaShark starts up. As queuing information forms part of a Task object, there is no danger of the queue states being lost, in the event of a system crash for example, as all Task files are written to disk.

If the operator selects several Tasks to add to a queue (a multiple selection), Tasks will be added as if they had been selected individually and in the order they appear in the Task List window. To change the order in which Tasks are processed, they must be added to a queue individually in the required order of processing.

5 FILE FORMATS

This section defines the file formats used within the SeaShark project.

5.1 AVHRR HRPT Product

The processing of an AVHRR HRPT pass requires the presence of two files after the acquisition:

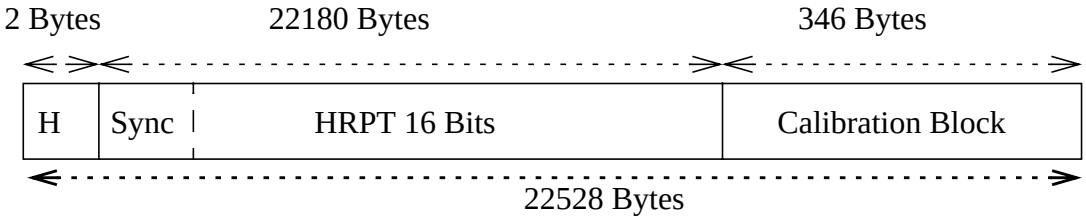
- the AVHRR HRPT Level 0 file coming from the satellite,
- the “AQTIM.DAT” file generated by the acquisition software.

5.1.1 AVHRR HRPT Level 0 File Formats

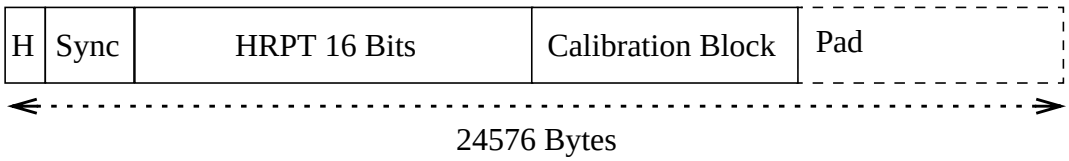
The AVHRR HRPT Level 0 format has a number of variants. The general form of the format is defined in “Data Extraction and Calibration of TIROS-N/NOAA Radiometers”, Rev. 1, Technical Memorandum NESS-107, dated October 1988 from NOAA [39]. The variants are described below.

The AVHRR HRPT Level 0 file written by the acquisition software can be in one of three different formats that are acceptable to SeaShark:

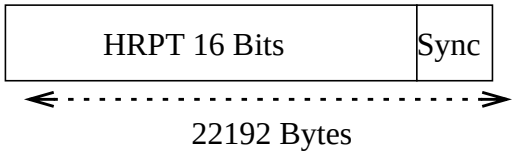
- the “DLR” type format, composed of a 2 Byte header, followed by a 16-bit HRPT data block containing a sync in 22180 Bytes followed by a Calibration data block in 346 Bytes: total length = **22548** Bytes;



- the “Dundee” type format, identical to the “DLR” type, but the total record length is blocked to a multiple of 8K (memory page size): total length= **24576** Bytes;



- a basic format without header or calibration data, composed of a 12 Bytes sync plus the 16-bit HRPT data in 22180 Bytes: total length= **22192** Bytes.



5.1.2 AQTIM.DAT File Format

This file is generated during the acquisition and is used to determinate the date of the pass (which is not present anywhere in the HRPT) and the first and last valid time lines. The AQTIM.DAT file is a text file. The format of the file is described in Table 5-1.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Format
1	sat_no	Satellite Number for NOAA	1	3	3	ASCII : ∇*nn*
		new-line char	4	4	1	
2	acq_start_date	Acquisition start date	5	10	6	ASCII : *YYMMDD*
		new-line char	11	11	1	
3	acq_start_time	Acquisition start time	12	20	9	ASCII : *HHMMSSmmm*
		new-line char	21	21	1	
4	acq_stop_date	Acquisition stop date	22	27	6	ASCII : *YYMMDD*
		new-line char	28	28	1	
5	acq_stop_time	Acquisition stop time	29	37	9	ASCII : *HHMMSSmmm*
		new-line char	38	38	1	
6	no_scan_lines	Number of scan lines within the passage	39	42	4	ASCII : *nnnn*
		new-line char	43	43	1	

Table 5-1 AQTIM.DAT Format

Note: The start and stop dates and times refer to the times of the first and last lines in the HRPT file.

Example:

∇11
930828
074558987
930828
075341320
2775

where ‘∇’ represents a space character.

5.2 SeaWiFS HRPT Product

The processing of a SeaWiFS HRPT pass requires only the SeaWiFS HRPT Level 0 file.

There is no currently defined SeaWiFS equivalent of the AVHRR AQTIM.DAT file (an empty file is used to trigger import [11]).

5.3 SeaWiFS HRPT Level 0 File Formats

There are three formats of the SeaWiFS HRPT Level 0 file accepted by SeaShark. The first is the raw HRPT data as acquired from the satellite [38]. SeaShark also accepts HRPT data as reformatted by acquisition software into either NASA Frame Formatter Level 0 [40] or HMF SeaWiFS HRPT format [45].

The HMF SeaWiFS HRPT data format, in use for example at Scanzano ground station, contains a series of Image Data Records (one per minor frame) each of which is formatted A described in Table 5-4.

It is important to note that in the HMF Image Data Record the raw 10-bit HRPT data words are unpacked to 16-bit short words (I*2) and that all short words are byte-swapped :
i.e. a 10-bit word '`abcdefghij`', where '`a`' is the most significant bit and '`j`' is the least significant bit, is stored in a 16-bit short word as '`cdefghij000000ab`'. Further, it should also be noted that whilst the State-of-Health field within the raw HRPT data consists of a series of 8-bit words, this data is unpacked as if it were a series of 10-bit words. This packing of the data fields is dealt with accordingly by SeaShark during the import process.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Frame_Sync	HRPT Frame Sync (6 × 16-bit words)	1	12	12	unsigned short	6
2	Spacecraft_ID	Spacecraft Identifier (2 × 16-bit words)	13	16	4	unsigned short	2
3	Time_Tag	Spacecraft time tag (4 × 16-bit words)	17	24	8	unsigned short	4
4	SOH_TLM	Spacecraft state of health telemetry (775 × 8-bit words unpacked into 620 × 16-bit words as if from 10-bit data)	25	1264	1240	unsigned short	775
5	Inst_Anc_TLM	SeaWiFS instrument and ancillary telemetry (44 × 16-bit words)	1265	1352	88	unsigned short	44
6	Gain_TDI	Gain and TDI for the 8 bands (8 × 16-bit words)	1353	1368	16	unsigned short	8
7	Start_Sync	Start sync for the SeaWiFS imagery (8 × 16-bit words)	1369	1384	16	unsigned short	8
8	Dark_Restore	Dark restore pixels for the 8 bands (8 × 16-bit words)	1385	1400	16	unsigned short	8
9	Image_Data	Pixel interleaved SeaWiFS image data for the 8 bands, 1285 pixels per scan line (1285 × 8 × 16-bit words)	1401	21960	20560	unsigned short	10280
10	Stop_Sync	Stop sync for the SeaWiFS imagery (8 × 16-bit words)	21961	21976	16	unsigned short	8
11	Pad	Pad (2 × 16-bit words)	21977	21980	4	unsigned short	2
12	Aux_Sync	HRPT auxiliary sync (100 × 16-bit words)	21981	22180	200	unsigned short	100

Table 5-2 Format of the HMF SeaWiFS HRPT Image Data Record

5.4 SeaWiFS and AVHRR Level 1 Archive Product

A Level 1 Archive Product contains the files listed in Table 5-3. The formats of most of these files are the same for SeaWiFS and AVHRR products; where there are differences, these are explained in the text.

File Type	Format
imagery file	see Section 5.4.1
navigation data file	see Section 5.4.2
land/sea mask file	see Section 5.4.3
coastline file (a)	see Section 5.4.4
calibration data file (b)	see Section 5.4.5
quicklook file	see Section 5.4.6
postscript quicklook file	see Section 5.4.7
catalogue entry file	see Section 5.4.8
acquisition details file (c)	see Section 5.4.9
orbit data file	see Section 5.4.10

Table 5-3 Files in a Level 1 Archive Product

(a) temporary file: exists only on disk when the product is first generated.
(b) AVHRR only.
(c) temporary file: exists only on disk when the product is first generated (SeaWiFS only).

5.4.1 Imagery File

The SeaWiFS imagery file contains a number of Image Data records, each of which is formatted as described in Table 5-4.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Scan_Line_Flag1	Scan line flag	1	2	2	unsigned short	1
2	Scan_Line_Day	Scan line day (Day of Year)	3	4	2	unsigned short	1
3	Scan_Line_Time	Scan line time (millisecs of day)	5	8	4	unsigned short	2
4	blanks		9	9	1	ASCII	1
5	Spacecraft_ID	Spacecraft Identifier (2 × 16-bit words)	10	13	4	unsigned short	2
6	Spacecraft_Time_Tag	Spacecraft time tag (4 × 16-bit words)	14	21	8	unsigned short	4

Table 5-4 Format of the SeaWiFS Level 1 Image Data Record

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
7	Spacecraft_SOH	Spacecraft state of health telemetry (775 × 8-bit words)	22	796	775	byte	775
8	Intstrument_Telemetry	SeaWiFS instrument and ancillary telemetry (44 × 16-bit words)	797	884	88	unsigned short	44
9	Gain_TDI	Gain and TDI for the 8 bands	885	900	16	unsigned short	8
10	Start_Synch_Pixel	Start synch pixel for the 8 bands	901	916	16	unsigned short	8
11	Dark_Restore_Pixel	Dark restore pixels for the 8 bands	917	932	16	unsigned short	8
12	Image_Data	Pixel interleaved SeaWiFS data (1285 pixels per scan line)	933	21492	20560	Structure: Table 5-5	1285
13	Stop_Synch_Pixel	Stop synch pixels for the 8 bands	21493	21508	16	unsigned short	8

Table 5-4 Format of the SeaWiFS Level 1 Image Data Record

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Band_1	Band 1 of the SeaWiFS sensor	N/A	N/A	2	unsigned short	1
2	Band_2	Band 2 of the SeaWiFS sensor	N/A	N/A	2	unsigned short	1
3	Band_3	Band 3 of the SeaWiFS sensor	N/A	N/A	2	unsigned short	1
4	Band_4	Band 4 of the SeaWiFS sensor	N/A	N/A	2	unsigned short	1
5	Band_5	Band 5 of the SeaWiFS sensor	N/A	N/A	2	unsigned short	1
6	Band_6	Band 6 of the SeaWiFS sensor	N/A	N/A	2	unsigned short	1
7	Band_7	Band 7 of the SeaWiFS sensor	N/A	N/A	2	unsigned short	1
8	Band_8	Band 8 of the SeaWiFS sensor	N/A	N/A	2	unsigned short	1

Table 5-5 Format of the SeaWiFS Image_data Structure

The AVHRR imagery file contains a number of Image Data records, each of which is formatted as described in Table 5-6.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Scan_Line_Flag1	Scan line flag	1	2	2	unsigned short	1
2	Scan_Line_Day	Scan line day (Day of Year)	3	4	2	unsigned short	1
3	Scan_Line_Time	Scan line time (millisecs of day)	5	8	4	unsigned short	2
4	Spacecraft_ID	Spacecraft Identifier (2 × 16-bit words)	9	12	4	unsigned short	2
5	Spacecraft_Time_Tag	Spacecraft time tag (4 × 16-bit words)	13	20	8	unsigned short	4
6	Telemetry	Spacecraft calibration telemetry	21	40	20	unsigned short	10
7	Backscan	Backscan data	41	100	60	unsigned short	30
8	Space_data	Space data	101	200	100	unsigned short	50
9	Sync	Synchronisation word	201	202	2	unsigned short	1
10	TIP_data	TIP data	203	1242	1040	unsigned short	520
11	Spare_words	Unused space	1243	1496	254	unsigned short	127
12	Image_data	Image data	1497	21976	20480	Structure: Table 5-7	2048
13	Auxiliary_sync	Auxiliary synchronisation word	21977	22176	200	unsigned short	100

Table 5-6 Format of the AVHRR Level 1 Image Data Record

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Band_1	Band 1 of the AVHRR sensor	N/A	N/A	2	unsigned short	1
2	Band_2	Band 2 of the AVHRR sensor	N/A	N/A	2	unsigned short	1
3	Band_3	Band 3 of the AVHRR sensor	N/A	N/A	2	unsigned short	1
4	Band_4	Band 4 of the AVHRR sensor	N/A	N/A	2	unsigned short	1
5	Band_5	Band 5 of the AVHRR sensor	N/A	N/A	2	unsigned short	1

Table 5-7 Format of the AVHRR Image_data Structure

5.4.2 Navigation Data File

The Navigation Data File contains the values of latitude, longitude, sun elevation, sun azimuth, satellite elevation and satellite azimuth for a regular grid of points within the product.

The navigation data file is a binary file consisting of a header record followed by a series of data records holding the tie point information. The header record is forced to be the same size as the data records to give the file a fixed record length. The actual record length is dependent on the number of tie points that are calculated for each line. It can be calculated as follows.

$$\text{record\_length} = \text{sizeof}(\text{ line\_status\_info}) + [\ \text{tie\_points\_per\_line} \times \text{sizeof}(\text{ int }) \times \text{angles\_per\_tie\_point }]$$

So for AVHRR products where 65 points are calculated per line:

$$\text{record\_length} = 8 + [65 \times 4 \times 6] = 1568 \text{ Bytes.}$$

For SeaWiFS products where 55 points are calculated per line:

$$\text{record\_length} = 8 + [55 \times 4 \times 6] = 1328 \text{ Bytes.}$$

The number of data records in the file is the same as the height of the related image. This gives a one to one relationship between image line and navigation line. The navigation data lines are calculated in one of two ways: by direct calculation from the predicted orbital position of the satellite using the Puccinelli algorithm, or by interpolation from the directly calculated values.

Note that in SeaShark the regular grid of points is forced to have a row spacing exactly equal to one pixel. During the navigation process grid lines are calculated with a spacing greater than one (for performance reasons) and then the intermediate line values are interpolated from the calculated ones.

The navigation data file is binary with the format shown in Table 5-8.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Grid_Dims	Dimensions of the navigation grid.	1	Variable[a]	Variable	Structure: Table 5-9	1
2	Grid_Row	Row of grid point values	1	Variable[b]	Variable	Structure: Table 5-10	Variable[c]

Table 5-8 Format of the Navigation Data

a. The size of the Grid_Dims structure is fixed at 36 bytes. However, to maintain a fixed record length within the file the record is null padded so that its length matches the length of the following Grid_Row records.

b. The length and stop byte are dependent on the number of navigation grid points per line. This parameter is defined in the Grid_Dims structure (see Table 5-9).

c. The number of Grid_Row records in the file is defined by the height of the source product's image defined in the Grid_Dims structure (see Table 5-9).

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Grid_Cols	Width of the grid.	1	4	4	unsigned int	1
2	Calculated_ Rows	Number of grid lines within the file which were calculated using the Puccinelli algorithm [14]	5	8	4	unsigned int	1
3	X_Spacing	Gap between grid columns.	9	12	4	unsigned int	1
4	Y_Spacing	Grid spacing between the grid rows that were calculated using the Pucinelli algorithm	13	16	4	unsigned int	1
5	X_Origin	Number of first column with a grid point (Numbered from 0).	17	20	4	unsigned int	1
6	Y_Origin	Number of first row in the file which was calculated using the Pucinelli algorithm [14]	21	24	4	unsigned int	1
7	Image_ Width	Width of the product's image.	25	28	4	unsigned int	1
8	Image_ Height	Height of the product's image.	29	32	4	unsigned int	1
8	Record_Len	Length of the Grid_Row records in the file in bytes.	33	36	4	unsigned int	1
8	Pad	Null padding to give the file a fixed record length.	37	Record _Len	(Record_ Len – 36)	unsigned int	Variable

Table 5-9 Format of the Grid Dimensions structure

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Scan_line_ flag	Copy of the scan line flag from the product's image with an additional flag defining if the line was calculated or interpo-lated.	1	2	2	Binary : unsigned short	1
2	Day_ Numb	Day of year of the line	3	4	2	unsigned short	1
3	Milliseconds	Millisecond since midnight of the line.	5	8	4	unsigned int	1
2	Grid_Point Values	Definition of the lat, long, sun and satellite angle at a grid point.			24	Structure: Table 5-11	Variable[a]

Table 5-10 Format of the Grid Row structure

a. Number of grid points per line is defined in the Grid Dimension structure (see Table 5-9)

The relationship between some of the entities from Table 5-9 is illustrated in Figure 5-1.

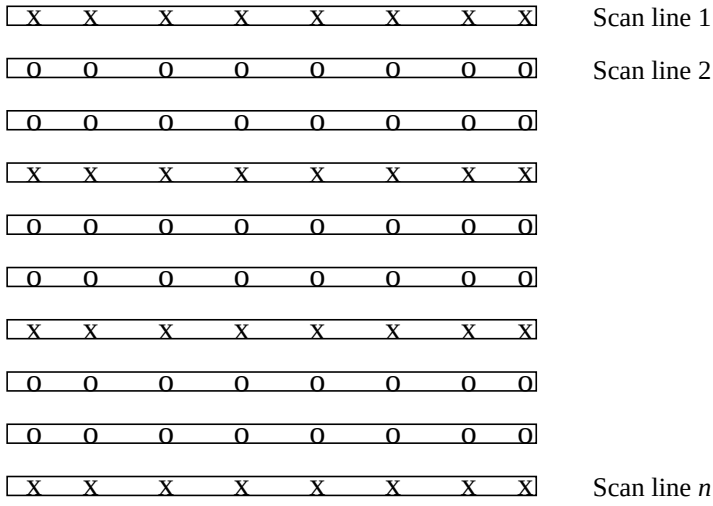

x x x x x x x x
Scan line 1
o o o o o o o o
Scan line 2
o o o o o o o o
x x x x x x x x
o o o o o o o o
o o o o o o o o
x x x x x x x x
o o o o o o o o
o o o o o o o o
x x x x x x x x
Scan line *n*

Figure 5-1 Grid Dimensions structure

x = navigated pixel
o = interpolated pixel
Calculated_Rows = number of scan lines containing x
Y_Spacing = the gap (number of scan lines) between scan lines containing x
Y_Origin = the number of the first scan line containing x

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Latitude	Longitude of the Grid Point (–180 to 180 degrees)			4	int	1
2	Longitude	Latitude of the Grid Point. (–90 to 90 degrees)			4	int	1
3	Sun_Azim	Sun azimuth angle at the grid point (–180 to 180 degrees)			4	int	1
4	Sun_Elev	Sun elevation angle at the grid point (–90 to 90 degrees)			4	int	1
5	Sat_Azim	Satellite azimuth angle at the grid point (–180 to 180 degrees)			4	int	1
6	Sat_Elev	Satellite elevation angle at the grid point (–90 to 90 degrees)			4	int	1

Table 5-11 Format of the Grid Point Values structure

All values are stored in units of 1/1000th of a degree.

5.4.3 Land Sea Mask File

The Land Sea Mask file contains a binary image with the same dimensions as the product's image. The pixels of this image hold classification (e.g. land or sea, coastline, etc) information about the equivalent pixel in the product image. The land sea mask file is made up of a series of land sea mask records. The format of the Land Sea Mask Record is shown in Table 5-12.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Scan_ line_ flag	Copy of the scan line flag from the product's image	1	2	2	Binary : unsigned short	1
2	Day_ Numb	Day of year of the line	3	4	2	unsigned short	1
3	Millisec-onds	Millisecond since midnight of the line.	5	8	4	unsigned int	1
4	Classificati on_ Flags	Classification information for 1 scan line of image data.	9	1293 *or* 2056[a]	1285 *or* 2048[a]	Structure : Table 5-13	1285 *or* 2048[a]

Table 5-12 Format of the Land Sea Mask Record

(a) The width of the classification field is 1285 bytes for SeaWiFS and is 2048 bytes for AVHRR.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Classifica-tion	Bit mask holding the following classification: Bit 1: Coastline flag Bit 2: Political Boundary flag Bit 3: Grid Line flag Bit 4: Sea flag Bits 5-8 : Free for future use			1	Binary : 1 byte	1

Table 5-13 Format of the Classification Flags structure

5.4.4 Coastline File

The Coastline File contains the coastlines and political boundaries extracted from the DCW in vector format so they can be easily overlaid on the product's image. The coastline and boundary vectors are stored in the binary format detailed in Table 5-14.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	No_Segs	Number of coastline segments in the file	1	4	4	int	1
2	Segment	Segment of coastline or politi-cal boundary.	5	Varia-ble[a]	Variable[a]	Structure : Table 5-15	No_Segs

Table 5-14 Format of the Coastline File

a. The size of the Segment record is variable, dependent on the number of points in each segment.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	No_Points	Number points in the segment	1	4	4	int	1
2	Type	Segment type (DCW defined).	5	8	4	int	1
3	Earth_ Extent	Range of latitude and longitude values in the segment.	9	24	16	Structure : Table 5-16	1
4	Image_ Extent	Minimum image row of any point in the segment	25	40	16	Structure : Table 5-17	1
5	Coastline_ Point	Coordinates of a segment point.	41	Varia-ble	16× No_Points	Structure : Table 5-18	No_Points

Table 5-15 Format of the Segment structure

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Max_lon	Maximum longitude of any point in the segment.[a]	9	12	4	int	1
2	Min_lon	Minimum longitude of any point in the segment.	13	16	4	int	1
3	Max_lat	Maximum latitude of any point in the segment.	17	20	4	int	1
4	Min_lat	Minimum latitude of any point in the segment.	21	24	4	int	1

Table 5-16 Format of the Earth Extent structure

a. All values in the Earth Extent structure are in units of degrees / 1000000. Longitude values are in the range [0, 360], latitude values are in the range [–90, 90].

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Max_row	Maximum image row of any point in the segment	25	28	4	int	1
2	Min_row	Minimum image row of any point in the segment	29	32	4	int	1
3	Max_col	Maximum image column of any point in the segment	33	36	4	int	1
4	Min_col	Minimum image column of any point in the segment	37	40	4	int	1

Table 5-17 Format of the Image Extent structure

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Latitude	Latitude of the segment point. [–90, 90] in degrees / 1000000			4	int	1
2	Longitude	Longitude of the segment point. [0, 360] in degrees / 1000000			4	int	1
3	Image_row	Image row of the segment point			4	int	1
4	Image_col	Image column of the segment point			4	int	1

Table 5-18 Format of the Coastline Point structure

5.4.5 Calibration Data File (AVHRR Only)

The calibration data file holds the sensor code in a header record whose format is shown in Table 5-19.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Sensor_Code	Three-character sensor code	1	3	3	ASCII	1

Table 5-19 Format of the Calibration Data Header record

The file also holds slope and intercept values for converting the raw image values to radiance for each of the 3 thermal bands. Slope and intercept values are calculated for every line of image data and are stored in the calibration data file as a series of records whose format is shown in Table 5-20.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
1	Scan_line_flag	Copy of the scan line flag from the product's image	1	2	2	Binary: unsigned short	1
2	Day_Numb	Day of year of the line	3	4	2	unsigned short	1
3	Millisec-onds	Millisecond since midnight of the line	5	8	4	unsigned int	1
4	BB_Temp	Average black body tempera-ture derived from the 4 PRTs	9	12	4	int	1
5	Band3_Slope	Slope of calibration for band 3	13	16	4	int	1
6	Band4_Slope	Slope of calibration for band 4	17	20	4	int	1
7	Band5_Slope	Slope of calibration for band 5	21	24	4	int	1

Table 5-20 Format of the Calibration Data Record

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type	Times
8	Band3_ Intercept	Intercept of calibration for band 3	25	28	4	int	1
9	Band4_ Intercept	Intercept of calibration for band 4	29	32	4	int	1
10	Band5_ Intercept	Intercept of calibration for band 5	33	36	4	int	1

Table 5-20 Format of the Calibration Data Record

Slope values are multiplied by 2^{30} before being stored in the 4 byte integer.
Intercept values are multiplied by 2^{22} before being stored in the 4 byte integer.

5.4.6 Quicklook Product

The quicklook product is in standard Sunraster 24-bit RGB format.

5.4.7 Postscript Quicklook File

The postscript quicklook file is a hardcopy summary of the product. The file is in Adobe postscript version 1.0 format and adheres to the specification in [30].

An example postscript quicklook file is shown in Figure 5-2.

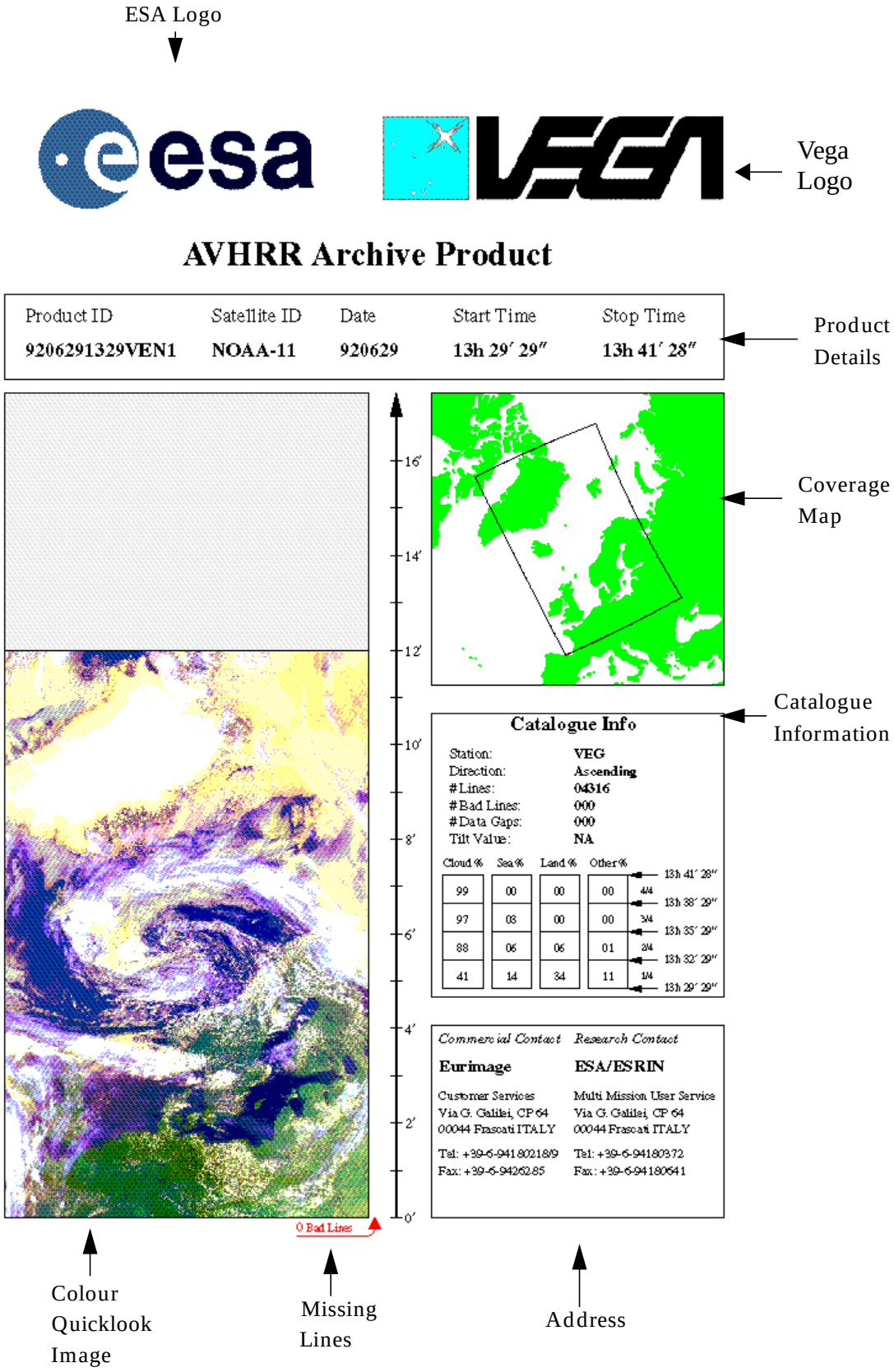


Figure 5-2 Postscript Quicklook File

5.4.8 Catalogue Entry File

The format of the Catalogue Entry File is based on the format given by [26]. However, the catalogue entry file ‘catalogue.iuf’, distributed as part of the Level 1 Archive Product, differs from this format as follows:

- it contains no header;
- it contains no trailer;
- it contains no newline characters.

The file size is therefore exactly 720 bytes.

5.4.9 Acquisition Details File

For AVHRR products the acquisition details are stored in the AQTIM.DAT file (see Section 5.1.2) which is updated so that the start and stop times correspond to the archive image product.

There is no acquisition details file stored with a SeaWiFS Level 1 Archive Product.

5.4.10 Orbit Data File

For AVHRR a TBUS file is used. The format is described in [35].

For SeaWiFS a TLE file is used. The format is described in [34].

5.4.11 ArchiveTape Index File

The archive tape index file is created on archiving a level1 product. See Table 5-21 and Table 5-22.

No	Name	Short Description	Start Byte	End Byte	Size in Bytes	Type
1	Header	Identifies file	1	52	52	ASCII
2	new line char		53	53	1	ASCII char \012

Table 5-21 Archive Tape index file header record

No	Name	Short Description	Start Byte	End Byte	Size in Bytes	Type
1	Product id	Identifies Product	1	16	16	ASCII
2	Date	The date the level1 product was archived	17	26	10	ASCII

Table 5-22 Archive Tape index file data record

No	Name	Short Description	Start Byte	End Byte	Size in Bytes	Type
3	Time	The time the level1 product was archived	27	37	11	ASCII
4	Size	The size in Mb of the archive product	38	51	13	ASCII
5	Offset	The offset of the archive product on the tape.	52	52	1	ASCII
6	new line char		53	53	1	ASCII char \012

Table 5-22 Archive Tape index file data record

5.5 Fast Delivery Product

The SeaShark Fast Delivery Product (FDP) consists of two files:

- a binary image file;
- a text description file.

5.5.1 Image File

The image is generated in raw format. The image data is stored row-wise with one byte per pixel, ho header or trailer and no internal compression. The file size is as recorded in the description file (normally 512×512).

The image file is transformed to GIF format if this is specified in the order.

5.5.2 Description File

The description file is a text file containing the information shown in Table 5-23.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
1	mission_id	mission identifier	1	3	3	ASCII : e.g. SS1 or N11
	blank		4	4	1	
2	sensor_id	sensor identifier	5	7	3	ASCII : SWF or AVH
	blank		8	8	1	
3	pro_level	product level	9	3	3	ASCII : FDP
	blank		12	12	1	
4	pro_type	product type	13	20	8	ASCII : e.g. SST or NDVI
	blank		21	21	1	

Table 5-23 Format of the FDP Description File

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
5	pro_sw_id	software id and version	22	33	12	ASCII : e.g. SeaShark_2.0
	blank		34	34	1	
6	pro_center	processing centre	35	37	3	ASCII : e.g. TMS
	blank		38	38	1	
7	acq_date	acquisition date	39	44	6	ASCII : YYMMDD
	blank		45	45	1	
8	l1_pro_id	original level 1 product id	46	59	14	ASCII : e.g. 9308280745TMN1
	blank		60	60	1	
9	pro_date	processing date	61	66	6	ASCII : YYMMDD
	blank		67	67	1	
10	img_form	output image format	68	70	3	ASCII : e.g. RAW or GIF
	blank		71	71	1	
11	byte_pix	number of bytes per pixel	72	72	1	ASCII : n
	blank		73	73	1	
12	img_samp	image sub-sampling factor	74	75	2	ASCII : nn
	blank		76	76	1	
13	img_width	output image width	77	80	4	ASCII : nnnn
	blank		81	81	1	
14	img_height	output image height	82	85	4	ASCII : nnnn
	blank		86	86	1	
15	num_pix_x	number of pixels extracted in x	87	90	4	ASCII : nnnn
	blank		91	91	1	
16	num_pix_y	number of pixels extracted in y	92	95	4	ASCII :nnnn
	blank		96	96	1	
17	img_project	image projection	97	104	8	ASCII : e.g. SATELLIT or MERCATOR
	blank		105	105	1	
18	lat_centre	latitude of the image centre	106	112	7	ASCII : +/-F6.3
	blank		113	113	1	
19	lon_centre	longitude of the image centre	114	121	8	ASCII : +/-F6.3
	blank		122	122	1	

Table 5-23 Format of the FDP Description File

The FDP format is described by [42].

5.6 Level 1 Distribution Product

The format of the SeaWiFS Level 1A distribution product is as defined in [24].

The format of the SeaWiFS Level 1B distribution product is as defined in [25].

The format of the AVHRR Level 1 distribution product is as defined in [20].

5.6.1 IMAGE File

Refer to [19].

5.6.2 LEADER File

Refer to [19].

5.6.3 NULL_VDF File

Refer to [19].

5.6.4 TRAILER File

Refer to [19].

5.6.5 VDF File

Refer to [19].

5.6.6 Distribution Tape Index File

The tape distribution index file is created on distribution of an order. See Table 5-26 and Table 5-27.

5.6.7 Order Status file

The order status file contains information on the status of the distribution product.

Refer to [35] for complete description.

No	Name	Short Description	Start byte	Stop Byte	Size in Bytes	Type
1	space	space	1	1	1	ASCII char \032
2	Order date	*yymmdd* where *yy* = year *mm* = month *dd* = day	2	7	6	ASCII
3	space	space	8	8	1	ASCII char \032

Table 5-24 Order status file data Record

No	Name	Short Description	Start byte	Stop Byte	Size in Bytes	Type
4	Ground station	e.g. VEG	9	11	3	ASCII
5	space	space	12	12	1	ASCII char \032
6	ESA order code		13	22	10	ASCI
7	Sub order number	leading zeros are not printed	23	26	4	ASCII
8	Order status	leading zeros are not printed	27	32	6	ASCII
9	Order priority	Priority is from 1(lowest) to 9(highest)	33	38	6	ASCII
10	CCT rejection flag		39	44	6	ASCII
11	Film rejection flag	ddddd0	45	50	6	ASCII
12	Shipping date	ddddd0	51	58	8	ASCII
13	New line char		59	59	1	ASCII

Table 5-24 Order status file data Record

5.6.8 Order file

The order file is automatically or manually created in order to create a distribution product.

Refer to [35] for complete description.

No	Name	Short Description	Start byte	Stop Byte	Size in Bytes	Type
1	space	space	1	1	1	ASCII char \032
2	ESA Order code	*aaaddddxyy* where *aaa* = station code *dddd* = counter *x* = order type (* -) *yy* = year	2	11	10	ASCII
3	space	space	12	12	1	ASCII char \032
4	sub order number	*dddd* where leading zeros are not printed	13	16	4	ASCII
5	space	space	17	17	1	ASCII char \032
6	Satellite id	Satellite id	18	18	1	ASCII

Table 5-25 Order file data Record

No	Name	Short Description	Start byte	Stop Byte	Size in Bytes	Type
7	Satellite Mission number	Satellite mission number	19	20	2	
8	space	space	21	21	1	ASCII char \032
9	Sensor id	Sensor id (AVHRR or SWIFS)	22	26	5	ASCII
10	space	space	27	27	1	ASCII char \032
11	Product code	Product code	28	33	6	ASCII
12	Latitude	*cdd,mm* where *c* = compass direction *dd* = degrees *mm* = minutes	34	39	6	ASCII
13	space	space	40	40	1	ASCII char \032
14	Longitude	*cddd,mm* where *c* = compass direction *ddd* = degrees *mm* = minutes	41	47	7	ASCII
15	space	space	48	48	1	ASCII char \032
16	Latitude	*cdd,mm* where *c* = compass direction *dd* = degrees *mm* = minutes	49	54	6	ASCII
17	space	space	55	55	1	ASCII char \032
18	Longitude	*cddd,mm* where *c* = compass direction *ddd* = degrees *mm* = minutes	56	62	7	ASCII
19	space	space	63	63	1	ASCII char \032
20	start date	*dd-mmm-yy* where *dd* = date *mmm* = month *yy* = year	64	72	9	ASCII
21	space	space	73	73	1	ASCII char \032
22	end date	*dd-mmm-yy* where *dd* = date *mmm* = month *yy* = year	74	82	9	ASCII

Table 5-25 Order file data Record

No	Name	Short Description	Start byte	Stop Byte	Size in Bytes	Type
23	space	space	83	83	1	ASCII char \032
24	start time	*hh*:*mm*:*ss* where *hh* = hour *mm* = minute *yy* = year	84	91	8	
25	space	space	92	93	2	ASCII char \032
26	stop time	*hh*:*mm*:*ss* where *hh* = hour *mm* = minute *yy* = year	94	101	8	ASCII
27	space	space	102	103	2	ASCII char \032
28	Pass identi-fier	archive product id	104	117	14	ASCII
29	space	space	118	118	1	ASCII char \032
30	Order type	Order type	119	119	1	ASCII
31	Media type	Media used for delivery	120	123	4	ASCII
32	Product type	Product type, e.g. L1B or LFD1 etc	124	127	4	ASCII
33	Priority	Priority	128	128	1	ASCII
34	Product sta-tion	Product station e.g. VEG	129	131	3	ASCII
35	space	space	132	132	1	ASCII char \032
36	Destination code		133	136	4	ASCII
37	space	space	137	137	1	ASCII char \032
38	Shipping code		138	138	1	ASCII
39	space	space	139	140	2	ASCII char \032
40	Comments		141	218	78	ASCII
42	new line char		219	219	1	ASCII char \012

Table 5-25 Order file data Record

5.7 Level 2 Distribution Product

Level 2 SeaWiFS distribution products are formatted as specified by [43].

The formats of the AVHRR Level 2A and Level 2B distribution products are as defined in [21].

5.7.1 IMAGE File

Refer to [20].

5.7.2 LEADER File

Refer to [20].

5.7.3 NULL_VDF File

Refer to [20].

5.7.4 TRAILER File

Refer to [20].

5.7.5 VDF File

Refer to [20].

5.7.6 Distribution Tape Index File

The tape distribution index file is created on distribution an order. See Table 5-26 and Table 5-27

No	Name	Short Description	Start byte	Stop Byte	Size in Bytes	Type
1	Header	Identifies file	1	18	18	Distribu-tion Report
2	new line char		19	19	1	ASCII char \012

Table 5-26 Tape distribution index file header Record

No	Name	Short Description	Start byte	Stop Byte	Size in Bytes	Type
1	Product id	The order id	1	16	16	ASCII
2	Archive product id	The id of the level1 product	17	32	16	ASCII
3	start time	Either in *HH*:*MM*:*SS* or location	33	41	9	ASCII
4	stop time	Either in *HH*:*MM*:*SS* or location	42	50	9	ASCII
5	Order type	The order type	51	67	16	ASCII
6	Date	The date the order was distributed	68	75	8	ASCII
7	New line char		76	76	1	ASCII char: \012

Table 5-27 Tape distribution index file data record

5.7.7 Order status file

Refer to Section 5.6.7.

5.7.8 Order file

Refer to Section 5.6.8.

5.8 Report File

A report is a text file which describes the processing activities that have taken place at an acquisition station. There are three types of report:

- an acquisition and archiving report which describes the products which have been acquired and archived;
- a distribution report which describes the products which have been distributed to users;
- a media report which details the media which have been used.

All report types have the same basic structure which consists of two header lines followed by a variable number of report lines. The content of the lines varies according to the report type. The formats of the lines are now described.

The first header line identifies the type of report and is formatted as shown in Table 5-28.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
1	SeaShark_string	Identifies the report as a SeaShark report	1	8	8	ASCII : SeaShark
	blank		9	9	1	
2	type	Identifies the report type	10	35	26	ASCII : e.g. Distribution
	blank		36	36	1	
3	report_string	Identifies a report	37	42	6	ASCII : Report
	blank		43	43	1	
	endline		44	44	1	

Table 5-28 Format of the First Header Line of a Report

The second header line identifies the period for which the report is valid and is formatted as shown in Table 5-29.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
1	Title_text		1	14	14	ASCII : Report between∇
	blank		15	15		
2	start_date_and_time	start date and time of the report	16	27	12	ASCII : YYMMDDhhmmss

Table 5-29 Format of the Second Header Line of a Report

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
	blank		28	28	1	
3	link_text		29	33	5	ASCII : ∇and∇
	blank		34	34	1	
4	end_date_and_time	end date and time of the report	35	46	12	ASCII : *YYMMDDhhmmss*
	blank		47	47	1	
	endline	endline character	48	48	1	

Table 5-29 Format of the Second Header Line of a Report

where '∇' represents a space character.

The report line of the Acquisition and Archiving Report is formatted as shown in Table 5-30.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
1	date	date of the operation	1	10	10	ASCII : *YYYY-MM-DD*
	blank		11	11	1	
2	pass_ID	passage identifier	12	27	14	ASCII : *YYMMDDhhmmaass* where *aa* = acquisition station *ss* = sensor
	blank		28	28	1	
3	pass_start_time	start time of the acquired pass	29	47	19	ASCII : *YYYY-MM-DD-hh*:*mm*:*ss*
	blank		48	48	1	
4	pass_stop_time	stop time of the acquired pass	49	67	19	ASCII : *YYYY-MM-DD-hh*:*mm*:*ss*
	blank		68	68	1	
5	archived_start_time	start time of the archived pass (can be different from field 3)	69	87	19	ASCII : *YYYY-MM-DD-hh*:*mm*:*ss*
	blank		88	88	1	
6	archived_stop_time	stop time of the archived pass (can be different from field 4)	89	107	19	ASCII : *YYYY-MM-DD-hh*:*mm*:*ss*
	blank		108	108		
7	status		109	116	8	ASCII : e.g. acquired
	blank		117	117	1	

Table 5-30 Format of the Report Line of the Acquisition & Archiving Report

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
8	media_ID	medium identifier	118	131	14	ASCII : *SYYMMDDhhmmPPT* where *S* = sensor *YYMMDDhhmm* = format date *PP* = platter (if optical disc used) *T* = type (D[lt], E[xabyte])
	endline		132	132	1	

Table 5-30 Format of the Report Line of the Acquisition & Archiving Report

The report line of the Distribution Report is formatted as in Table 5-31

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
1	date	date of the operation	1	10	10	ASCII : *YYYY-MM-DD*
	blank		11	11	1	
2	order_#	ESA order code	12	21	10	ASCII : *AAADDDD-YY*
	blank		22	22	1	
3	sub_order_#	ESA sub-order #	23	26	4	ASCII : *nnnn*
	blank		27	27	1	
4	sub_order_stat	status of the sub-order	28	32	5	ASCII : e.g done or error
	blank		33	33	1	
5	pass_id	passage identifier	34	53	19	ASCII : *YYMMDDhhmmaass* where *aa* = acquisition station *ss* = sensor
	blank		53	53	1	
6	Prod_type	type of distributed product	54	57	4	ASCII : as defined by EPOORD
	blank		58	58		
7	media_ID	id of the medium used	59	73	14	ASCII : *SYYMMDDhhmmPPT* where *S* = sensor *YYMMDDhhmm* = format date *PP* = platter if optical disc used) *T* = type (D[lt], E[xabyte])
	endline		73	74	1	

Table 5-31 Format of the Report Line of the Distribution Report

The report line of the Media Report is formatted as in Table 5-32.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
1	date	date of the operation	1	10	10	ASCII : *YYYY-MM-DD*
	blank		11	11	1	
2	media_ID	id of the medium	12	27	14	ASCII : *SYYMMDDhhmmPPT* where *S* = sensor *YYMMDDhhmm* = format date *PP* = platter (if optical disc used) *T* = type (D[lt], E[xabyte])
	blank		28	28	1	
3	media_type	type of the medium	29	32	4	ASCII : e.g. OPT
	blank		33	33	1	
4	media_stat	status of the medium	34	43	10	ASCII : e.g. created
	blank		44	44	1	
5	archive_num	reference number of the media in the archive	45	58	14	ASCII
	endline	endline character	59	59	1	

Table 5-32 Format of the Report Line of the Media Report

5.9 Configuration File Format

The format of a configuration file is described below:

- a configuration file contains a number of lines;
- each line is either a comment line, which is ignored by the software, or a configuration line, which is read by the software;
- a comment line is any line whose first two non-space characters are '//'. Any text following the '//' characters contain the comment. Note that comments can also appear at the end of configuration lines;
- a configuration line contains name-value pairs, separated by an '=' character. The name contains the identifier of the configuration parameter (to the left of the equals symbol) and the value is everything to the right of the equals symbol up to the terminating semicolon. A configuration line can be any length and is terminated by a semicolon character;
- the value can, in fact, be a list containing several values, each of which is separated by white space characters;
- the order of the lines is not important but there are some relationships between different lines which must be preserved, for example when the numbers of values in one line must equal the number of values in another line. Such relationships are described in the file by means of comments.

The following extract from a configuration file illustrates these points:

```
// comment - the numbers of the NOAA satellites supported by the software
noaa_satellite_numbers = 9 10 11 12 ; // another comment
noaa9_channel4_start_wavelength = 555.43 ;
```

A complete list of all configurable parameters is given by the Software ser Manual [10].

5.10 Log File Format

The log file is the means by which a program indicates to SeaShark whether its processing has been successful. Every program in the processing chain must write such a log file since it is the means by which SeaShark maintains control. A Log File contains two lines:

Line 1: Contains two fields: Success and Error_code. The Success field is set to either 1, to indicate a successful status, or 0, for a failure. The Error_code is a program specific number which defines the cause of failure, if any.

Line 2: Contains a string describing the fault, if any.

The following example from a failed Level 0 import process illustrates the format:

```
0 77
Input image does not contain any valid GPS data
```

5.11 MEDIA FORMATS

This section details the formats used to store information on archive and distribution tapes.

It should be noted that individual fields within a format are written to tape using the Rogue-Wave class RWpostream and read in using RWpistream. These classes act as an ASCII veneer over an associated streambuf and are responsible for formatting variables and escaping characters in such a way that the results can be interchanged between machines. Therefore, the information in this section is only valid if these classes are used; reading the data off the tape using some other method may produce different results. See [41] for further information.

5.11.1 Archive Tape

An archive tape provides the means for the long term storage of Level 1 products. Products are written to the tape from where they can be retrieved at a later date. The tape contains a number of files which have been written to the tape in Unix *tar* format. The sequence of the files on the tape is shown in Table 5-37.

No	Name	Short Description	Format
1	Label	Tape identifier	Unix tar
2	Product_1	First archived product	Unix tar
3	Directory_1	First directory	Unix tar
4	Product_2	Second archived product	Unix tar
5	Directory _2	Second directory	Unix tar
	…		
2*n*	Product_*n*	*n*th archived product	Unix tar
2*n* +1	Directory_*n*	*n*th directory	Unix tar

Table 5-33 Archive Tape Format

Note: the Label and Directory tar files contain a single file named ‘SeaShark.dir’. The Product tar files contain a number of files as detailed below.

The first file provides a label which is used to identify the tape and distinguish different tapes in the archive. Following the label there are a series of file pairs. The first file of a pair contains an archived product, whilst the second contains a directory of the products on the tape up to that point. As new products are appended to the tape, the directory is extended to include their details.

When untarred from the tape a Label File has the format of Table 5-37.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
1	Header	Identifies the tape as a SeaShark archive tape.	1	13	13	ASCII : “SeaSharkDIR”
2	Identifier	Distinguishes different archive tapes.	14	29	16	ASCII : of the form “*AYYMMDDhhmmSST*” where: *A* = ([A]VHRR or [S]eaWiFS); *YYMMDDhhmm* = date & time written; *SS* = acquisition station; *T* = type (X for Exabyte).
3		Unused	30	30	1	ASCII : 0
4		new-line char	31	31	1	ASCII char : \012

Table 5-34 Archive Tape – Label Format

Note : the quote characters are part of the format for text strings.

The Label File is identical to an empty Directory File (see below).

A directory is the means of identifying and locating the products on the tape so that they can be retrieved. When untarred from tape, a Directory File has the format of Table 5-35.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
1	Header	Identifies the tape as a SeaShark archive tape.	1	13	13	ASCII : “SeaSharkDIR”
2	Archive_id	Distinguishes different archive tapes	14	29	16	ASCII : of the form “*AYYMMDDhhmmSST*” where: *A* = ([A]VHRR or [S]eaWiFS); *YYMMDDhhmm* = date & time written; *SS* = acquisition station; *T* = type (X for Exabyte).
3	Number of products	The number of products on the tape up to that point.	30		Var.	ASCII : e.g. 2 or 12
		new-line char	Var.	Var.	1	ASCII char : \012
4	Directory entry 1	Details of the first archived product.	Var.	Var.	Var.	Structure : Table 5-37
5	Directory entry 2	Details of the second archived product.	Var.	Var.	Var.	Structure : Table 5-37
...						
n+3	Directory entry *n*	Details of the *n*th archived product.	Var.	Var.	Var.	Structure : Table 5-37

Table 5-35 Archive Tape – Directory Format

Each directory entry describes one of the products on the tape. The format of a Directory Entry is given in Table 5-37.

No	Name	Short Description	Format
1	Time	Time the product was written to tape	internal format (RWTime)
		new-line char	
2	File name	Name of the product (Product ID)	ASCII : e.g. 9308280745TMN1
3	Size	Size of the product in bytes	ASCII
		new-line char	
4	Offset	Position of the product on the tape in terms of number of tar files (e.g. the first product has offset 1, etc.).	ASCII
		new-line char	

Table 5-36 Format of the Archive Tape Directory Entry

Product tar files contain nine datafiles which together form a single archive product. Each file is named with the Product_ID as a directory name to aid identification:
i.e. *ProductID*/*ProductFile*.

When untarred from the tape, each product expands into a number of files from which the product is composed. The files are automatically placed by SeaShark into a directory structured according to $SEASHARKHOME/data/*sensor*/Level1/*ProductID*.

The product files are listed in Table 5-37:

No	Name	Content
1	image.l1a	Image data
2	navigation	Navigation data
3	quicklook.rs	QuickLook
4	paper_ql.ps	Postscript QuickLook
5	land_sea_mask	Land / sea mask
6	catalogue.iuf	Catalogue entry
7	tbus / tle	Orbit data(a)
8	calibration	Calibration data(b)
9	AQTIM.DAT	Acquisition details(c)

Table 5-37 Archive Tape – Product Files

(a) SeaWiFS: tle; AVHRR: tbus
(b) and (c) AVHRR only

5.11.2 Distribution Tape

A distribution tape provides a means for delivering products to users. A distribution tape contains a number of files which have been written to the tape in Unix *dd* format. The sequence of

the files on the tape is shown in Table 5-38.

No	Name	Short Description	Format
1	Label		dd
2 - 6	Product 1	First distribution product	dd
7 - 11	Product 2	Second distribution product	dd
…	…	…	…
(5*n*–3) – (5*n*+1)	Product *n*	*n* th distribution product	dd

Table 5-38 Distribution Tape Format

The Label File is a simple 12 character text file of the format '*AAAddddddnnn*' where:
AAA is the station ID;
dddddd is the date in 'YYMMDD' format;
nnn is a unique tape number for that day.

Several files together form a single distribution product. They are written anonymously to tape in the order specified by the corresponding product definition document.

The distribution product file formats are as defined in earlier sections.

6 PROCESSING STEPS

6.1 Import

Import is the process of adding products to SeaShark.

6.1.1 HRPT import

The HRPT import process for AVHRR and SeaWiFS is very similar, SeaShark can import three different types of AVHRR HRPT and three types of SeaWiFS HRPT.

The stages of import are:

1) The import process is started by an AQTIM.DAT file with associated HRPT image file being placed in a sub directory.
2) Identification of the HRPT format. The mechanism is as follows:
   - For AVHRR, in turn assume the input image is in one of the possible formats.
   - For SeaWIFS, format identification relies on the invariant “CWIF” characters at the start of a Frame Formatted image; if these are not present then SeaShark assumes it is either a raw 10-bit HRPT or an HMF HRPT image depending on the setting of a flag in SeaShark.cfg (“use_SeaWiFS_HMF”).
   - Search for the first block of scan lines in the image with coherent time tags. This block must be greater in length than the coherent block length (defined in SeaShark.cfg “import_coherent_block_length”). The correct format of the image will return the lowest starting line number of this block. Data prior to the start of this first coherent block will be discarded as noisy data.
3) The first quality check of the image. This looks for bad or missing lines in the image by searching for incoherencies in the time tags of the HRPT records.
4) The output image is automatically split if one of the following 3 conditions are true:
   - The input HRPT image spans midnight UTC;
   - A sequence of bad, or missing lines are found in the image whose total length exceeds the product break length (defined in SeaShark.cfg “import_product_break_length”);
   - For SeaWiFS, the instrument tilt state changes. A new tilt state is recognised when a coherent block of scan lines, greather in length than the coherent tilt length (defined in SeaShark.cfg “import_coherent_tilt_length”) and thereby protecting against occasional noise affected tilt telemetry, shows a new tilt state. Image scan lines acquired during tilt transition are discarded.

The following files are created for the imported Level 0 product, or for each of the ‘split’ image products identified in step 4 :

- AQTIM.DAT AVHRR only. Refer to section 5.1.2 for description of file format.
- image.l1a Refer to section 5.4.1 for description of file format.
- catalogue.iuf Refer to section 5.4.8 for description of file format.

All the files that are created are temporarily stored in <*Product_ID*>.IMP directory but then moved to <*Product_ID*> directory on successful completion of all steps.

For the catalogue.iuf the elements filled after successful import are:

- MetaLine 1
  - Mission ID
  - Sensor ID
  - Data mode

  - Acquisition date
  - Start time
  - End time
  - Station ID
- Metaline2
  - Product ID
  - Band modes
  - Ql flag
- MetaLine3
  - Number of lines
  - Number of bad lines
  - Number of gaps
  - Delta time
  - Delta roll
  - Delta pitch
  - Delta yaw
- MetaLine4
- MetaLine5
- MetaLine6
- MetaLine7
- MetaLine8
- MetaLine9

If import fails, an error is reported to the user and an HRPT_IMAGE.LOG file is added to the import directory. The IMAGE_HRPT and AQTIM.DAT files remain unchanged.

After successful import the IMAGE_HRPT and AQTIM.DAT files are removed from the import directory.

Executables used are:

- SeaShark
- Import_AVHRR_Product (AVHRR)
- Import_SeaWiFS_Product (SeaWiFS)

6.1.2 Level 0 import

A product that is already at level 0 can be imported into SeaShark. (This is the case after stitching two products together.)

The import process is started by a catalogue.iuf file with associated AQTIM.DAT (for AVHRR) and image.l1a being placed in a sub directory. Refer to [9] for more detailed information.

Files copied:

- catalogue.iuf
- AQTIM.DAT (for AVHRR)
- image.l1a

Executables use are:

- SeaShark

Similar procedures apply to import of Level 1 archive products from the Archive (next step Archive) and Level1 (reference product) sub-directories.

6.2 The Navigation Process

A large number of the processing steps require SeaShark to calculate the geographical position of any pixels in an image. To offset this processing burden most of these calculations are done before the data is required.

The navigation process can be roughly broken down into three distinct stages:

1. locating the satellite's position, attitude and viewing geometry;

2. generating the navigation grid;

3. interpolating within the grid to find the pixel position of a given geographical position.

6.2.1 Locating the satellite's position, attitude and viewing geometry

In order to navigate an image and prepare a grid of geolocation tie-points it is necessary to determine the satellite's position and attitude at each grid line. In the case of SeaWiFS, where the instrument may be tilted to avoid sun-glint, the instrument viewing geometry must also be determined.

There are two possible methods for locating the satellite's position. The first is to use the orbital elements of the spacecraft as supplied by NASA or NOAA, the other is to use the GPS data taken at the time of the pass.

Orbital elements are parameters which exactly specify the orbit of a satellite. SeaShark can read this data in two forms: TLE and TBUS files. Typically, SeaShark will have a database of TLE files for the SeaStar satellite and a similar database of TBUS files for the NOAA series of satellites. This data is stored in the SeaShark orbit data directory which is subdivided into sensor types and dates.

If navigating by orbital elements (the only option for AVHRR), the first step in determining the satellite position is to find the correct orbital element file. SeaShark compares the time of the pass with the time of the orbital element files and chooses the file immediately prior to the time of the pass. If no orbital element file is found SeaShark reports this error to the user.

Once the orbital elements have been established SeaShark can propagate the orbit to the exact time of a particular scan line and determine the satellite's position. This is accomplished using ESRIN-provided orbit propagation algorithm.

If GPS navigation has been selected (only available for SeaWiFS) SeaShark uses the GPS data in the image file. GPS data is read out of the State Of Heath telemetry in the HRPT (see [38]). SeaShark searches for the GPS data set time-stamped as nearest to the image scan line. The position and velocity vectors found are propagated, as above, to determine the satellite position at the time of the current grid line. If SeaShark detects an error in the GPS data, for example if the satellite position suddenly changes beyond a set limit (these limits are set in the SeaShark

configuration file), SeaShark will disregard the value and interpolate from previous values. When no valid GPS data can be found an error is reported to the user.

The satellite's attitude is initially assumed to be nominal i.e. no attitude offsets from nadir view. This may be modified with regard to the roll angle during the 'Coastline Adjust' step (see section 6.2.5). If GPS navigation has been selected (only available for SeaWiFS) then the derived attitude information provided in the State of Health telemetry together with the GPS data is used (see [38]). Since the attitude is updated every 2 seconds the attitude change rates are not used by SeaShark to interpolate these attitude values. QA of these attitude values against valid limits, set in the SeaShark configuration file, is carried out as for the GPS data.

Finally, in the case of SeaWiFS, the instrument tilt is determined by examining the tilt state telemetry in the HRPT (see [38]). Depending on the tilt lock, instrument tilt of +20, 0 or –20 degrees is assigned. The AVHRR instrument does not tilt and so no adjustment to viewing geometry is required.

6.2.2 Generating the navigation grid

Now that the satellite position and attitude (with instrument tilt state for SeaWiFS) is known, the geographical position of evenly spaced pixels is calculated (the grid spacing is specified in the SeaShark configuration file). This information makes up the navigation grid. For each grid point, the interception of the instrument view with a geoid model of the Earth is made using the Puccinelli algorithm (see [14]) and the latitude/longitude, solar angles and satellite angles are recorded. Figure 6-1 below shows a navigation grid for a pass over North America.

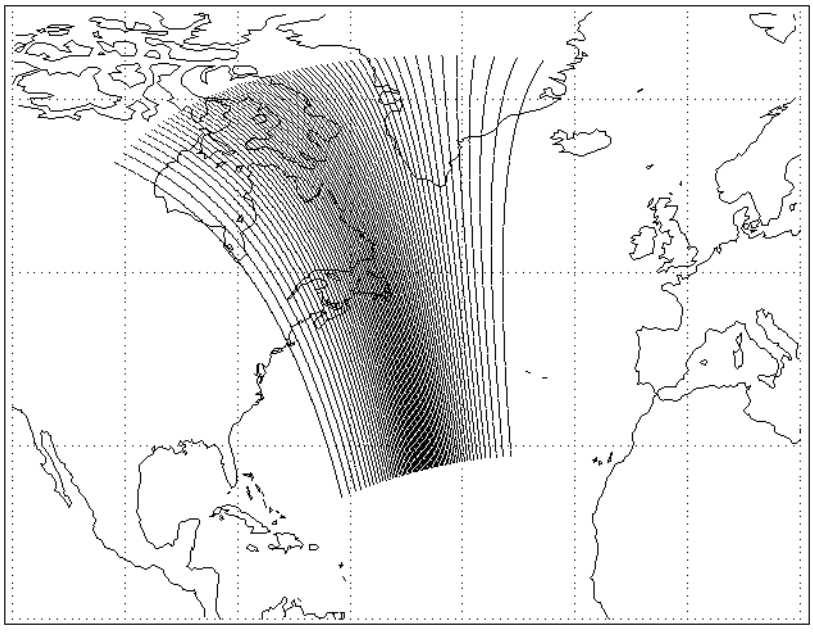


Figure 6-1 An example of an interpolated navigation grid

Once the navigation grid has been calculated the Interpolate_Navigation_Data program interpolates within the grid so that the *x* spacing of the grid is exactly equal to one pixel.

The last stage of the navigation process occurs when SeaShark needs to calculate the pixel position of a geographic coordinate. For example when generating the land sea mask.

6.2.3 Geographic location to pixel position

This is not a simple problem and requires a complex two dimensional search in the navigation grid to find the corresponding pixel position. The navigation grid is sub-divided into two blocks, the sizes of which are defined in the SeaShark configuration file. The navigation grid data (elevation and azimuth angles) is then projected into polar stereographic projection to avoid all problems with the discontinuity in azimuth angles and the poles of the elevation angle. For each block a set of affine coefficients is calculated. This defines a mapping from pixel position to geographical position.

The affine coefficients are the coefficients from the equation:

$$x = Ax_0 + Bx_1 + Cx_0x_1 + D$$
$$y = Ey_0 + Fy_1 + Gy_0y_1 + H.$$

An example of a coefficient matrix is shown below.

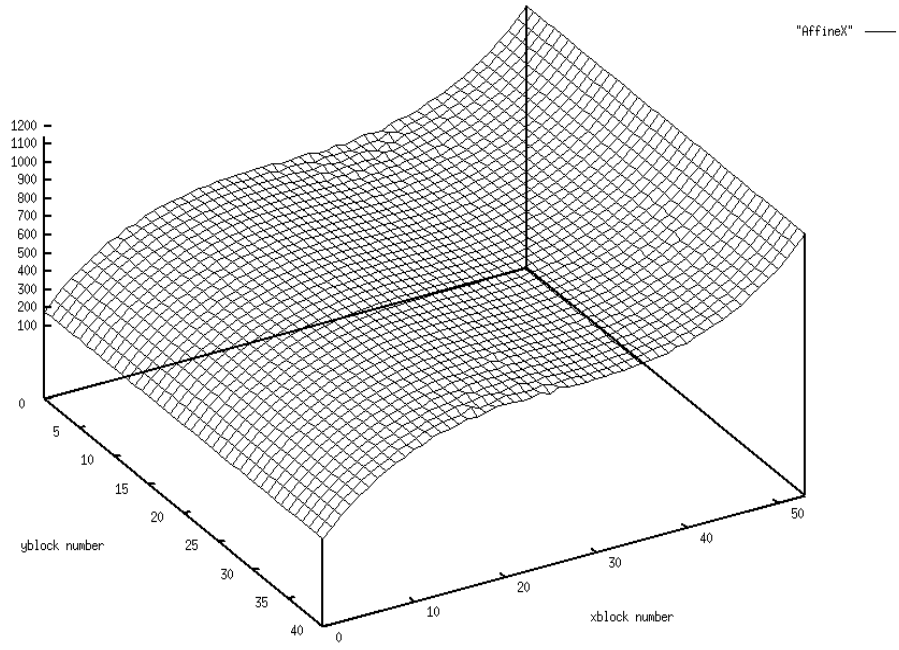


Figure 6-2 Graphical representation of an affine coefficient matrix

Once the affine coefficients have been calculated, geographical positions can be found using an iterative search using the affine values. The search algorithm uses either the last pixel position or the middle of the image as a starting point. The affine coefficients for this location are then used to calculate a better estimate of the pixel position for the geographical location. When the new estimate and the current pixel position are equal, the iteration stops. If the process has not converged after 100 iterations, the current iteration pixel position is used and the user is warned. If the pixel position of a geographical location outside the image is needed, an estimate is calculated using the affine values at the corresponding edge of the image.

6.2.4 Navigation data summary

Files created are:

- coastline
- navigation
- tbus (AVHRR)
- tle (SeaWiFS)

Files updated are:

- catalogue.iuf

For the catalogue.iuf the elements filled in are:

MetaLine3

- Ascending/Descending flag
- Tilt of Satellite (SeaWiFS)
- GPS navigation flag (SeaWiFS with Geographic Positioning
- System navigation used)
- tbus (AVHRR TBUS or SeaWiFS TLE)

Executables used are:

- SeaShark
- Get_Orbit_Data
- Navigate_AVHRR (AVHRR)
- Navigate_SeaWiFS_GPS (SeaWiFS)
- Navigate_SeaWiFS_TLE (SeaWiFS)
- Extract_Coastline

6.2.5 Coastline adjust

The Coastline which was obtained in the Navigation stage is visually displayed to the user and can be manually moved so a more exact match can be obtained (see [10]).

Files update are:

- coastline
- navigation
- catalogue.iuf

For the catalogue.iuf the element changed after successful coastline adjust are:

- Delta time
- Delta roll

The executables used are:

- SeaShark
- Navigate_AVHRR (AVHRR)
- Navigate_SeaWiFS_GPS (SeaWiFS)

- Navigate_SeaWiFS_TLE (SeaWiFS)
- Retransform_Coastline
- Set_Coastline_Offset

6.3 Level1

Creates and prepares files for archiving.

Files created are:

- calibration
- land_sea_mask
- paper_ql.ps
- quicklook.rs

Files updated are:

- navigation
- catalogue.iuf

For the catalogue.iuf the elements filled after successful process to level1 are:

- MetaLine 1
- MetaLine2
  - Station name
  - Product creation date (YYMMDD)
  - Product creation time (HHMMSS)
  - Product Software version id
  - Product Configuration version id
- MetaLine3
  - Orbit number
  - EQCRX time
  - EQCRX longitude
- MetaLine4
  - Percentage of image classified as cloud cover in quadrant1
  - Percentage of image classified as cloud cover in quadrant2
  - Percentage of image classified as cloud cover in quadrant3
  - Percentage of image classified as cloud cover in quadrant4
  - Percentage of image classified as Land in quadrant1
  - Percentage of image classified as Land in quadrant2
  - Percentage of image classified as Land in quadrant3
  - Percentage of image classified as Land in quadrant4
  - Percentage of image classified as Sea in quadrant1
  - Percentage of image classified as Sea in quadrant2
  - Percentage of image classified as Sea in quadrant3
  - Percentage of image classified as Sea in quadrant4
  - Percentage of image unclassified in quadrant1

    - Percentage of image unclassified in quadrant2
    - Percentage of image unclassified in quadrant3
    - Percentage of image unclassified in quadrant4
    - Id of classification algorithm used
- MetaLine5
    - Scan line number
    - Right Latitude
    - Right Longitude
    - Central Latitude
    - Central Longitude
    - Central Elevation
    - Left Latitude
    - Left Longitude
- MetaLine6
    - Scan line number
    - Right Latitude
    - Right Longitude
    - Central Latitude
    - Central Longitude
    - Central Elevation
    - Left Latitude
    - Left Longitude
- MetaLine7
    - Scan line number
    - Right Latitude
    - Right Longitude
    - Central Latitude
    - Central Longitude
    - Central Elevation
    - Left Latitude
    - Left Longitude
- MetaLine8
    - Scan line number
    - Right Latitude
    - Right Longitude
    - Central Latitude
    - Central Longitude
    - Central Elevation
    - Left Latitude
    - Left Longitude
- MetaLine9
    - Scan line number
    - Right Latitude
    - Right Longitude
    - Central Latitude
    - Central Longitude
    - Central Elevation
    - Left Latitude
    - Left Longitude

The executables used are:

- SeaShark
- Create_Land_Sea_Mask
- Extract_Calibration_Data
- Generate_AVHRR_Quicklook (AVHRR)
- Generate_SeaWiFS_Quicklook (SeaWiFS)
- Interpolate_Navigation_Data
- Update_AVHRR_CatEntry (AVHRR)
- Update_SeaWiFS_CatEntry (SeaWiFS)

6.4 Archive

The files created at the Level1 stage are copied onto archive tape.

Files updated are:

- catalogue.iuf
- *<Tape_id>*

Refer to Table 5-22, “Archive Tape index file data record,” on page 55.

For the catalogue.iuf the amendments are:

- MetaLine1
  - Archive centre
  - Archive tape id
  - Media type id

Executables used are:

- SeaShark
- Exabyte

6.5 Delete

Any files or directories relating to the product are deleted from disk.

6.6 Retain

The product is changed to a Level1 archive product from which distribution products can be created.

6.7 Orbit Stitching

There are two stages to orbit stitching, the first is calculating whether two or more passes can be successfully joined (stitched) together and the second is to perform the stitching.

Stage 1: Potential Stitch_Passes

Identifies passes from different ground-stations which are susceptible to being stitched into a more complete orbit according to timing criteria.

Stage 2: Stitch_Passes

Using the information ascertained from Stage 1, several passes from different ground-stations are combined to form a more complete orbit with the code OR. Passes may be specified by product name or timing criteria; all are assumed to be available in the local image directory. May be used with AVHRR and SeaWiFS imagery. An error is generated if a scanning is present in the optional passes but absent from the selected pass list.

For more information refer to [9].

6.8 Retrieve

Checks whether the necessary archive product exists on disk. If the archive product does not exist on disk the current archive tape is searched (or optical disk for optical retrieval). If the archive product does not exist on tape the retrieve fails. Refer to [9] for more information.

6.9 Generate

The distribution product files are created (or copied for optical Sharp1 products). In Table 6-1 and Table 6-2 are listed the files created for each type of distribution product and the executable used to create them.

Distribution product	Executable used	File created
Sharp1 (from archive product)	Create_AVHRR_Sharp1	VDF NULL_VDF LEADER IMAGE TRAILER
Sharp2A (from archive product)	Create_AVHRR_Sharp2A	VDF NULL_VDF LEADER IMAGE TRAILER
Sharp2B (from archive product)	Create_AVHRR_Sharp2B	VDF NULL_VDF LEADER IMAGE TRAILER
Sharp2A (from optical product)	Processes_Sharp1_to_2A	VDF NULL_VDF LEADER IMAGE TRAILER

Table 6-1 Distribution product types – AVHRR

Distribution product	Executable used	File created
Sharp2B (from optical product)	Processes_Sharp1_to_2B	VDF NULL_VDF LEADER IMAGE TRAILER
Fast Delivery Product for Normalised Difference Vegetation Index (only available from archive products)	Generate_FDP_NDVI	LFD1.raw LFD1.txt
Fast Delivery Product for Sea Surface Temperature (only available from archive products)	Generate_FDP_SST	SFD1.raw SFD1.txt

Table 6-1 Distribution product types – AVHRR

Distribution product	Executable used	File created
LAC1A (only available from archive products)	Create_SeaWiFS_LAC1A	VDF NULL_VDF LEADER IMAGE ANNOTATION
LAC1B (only available from archive products)	Create_SeaWiFS_LAC1B	VDF NULL_VDF LEADER IMAGE ANNOTATION
LAC 2 (only available from archive products)	Create_SeaWiFS_LAC2	VDF NULL_VDF LEADER IMAGE ANNOTATION
Fast Delivery Product for chlorophyll *a* (only available from archive products)	Generate_FDP_CHLA	CFD1.raw CFD1.txt

Table 6-2 Distribution product types – SeaWiFS

Refer to [9] for more information.

6.10 AVHRR Distribution Product OverView

The SHARP distribution products generated by SeaShark use the calibration algorithms defined in NOAA Technical Memorandum NESS 107 Data Extraction and Calibration of TIROS-N/NOAA Radiometer [39].

SHARP L1B:
The L1B product contains uncalibrated data for all available channels.

SHARP L2A:
The L2A product contains equivalent reflectance in channels 1 and 2, radiance in channel 3 and brightness temperature in channels 4 and 5 (with non-linearity correction). The method of calibration is discussed below in section 6.11.

SHARP L2B:
The L2B product contains class dependent geophysical parameters in channels 1 and 5. Channels 2,3,4 contain calibrated values as in above L2A product.

The algorithms used to generate the above products will now be briefly discussed with reference to SeaShark specific issues.

6.11 Calibration of visible AVHRR channels

The AVHRR visible channels have no in flight calibration data, and hence rely on pre-flight calibration data or for the odd numbered satellites, Holben coefficients.

6.11.1 Even numbered satellites

The effective albedo measured by the sensor for channel i is computed as a linear function of the input data value as follows:

$$C_i(l, c) = A_i \times \mathrm{CN}_i(l, c) + B_i, \text{ for } i = 1,2$$

Where,
$\mathrm{CN}_i(l, c)$ = digital counts band i for pixel of coordinates l, c
A_i = Slope value for band i
B_i = Intercept value for band i
$C_i(l, c)$=effective albedo band i for pixel of coordinates l, c.

Using effective albedo, the equivalent radiance r can be calculated thus,

$$r_i(l, c) = d_s^2 \times C_i(l, c) / \cos[\vartheta(l, c)]$$

where

$$d_s = 1 - 0.01672 \times \cos[0.9856 \times (\mathrm{DayOfYear} - 4)]$$

$\vartheta(l, c)$ = Solar zenith angle for pixel of coordinates l, c.

Internally SeaShark optimises this calculation by incorporating some of the constants into A_i and B_i which are constants throughout the image. Both the slope and intercept values are configurable and set in the detailed sensor configuration file.

6.11.2 Odd numbered satellites

The calibration of the odd numbered channels is base on the work done by Holben *et al*. This method more reliably compensates for the degradation of channels one and two over time.

When holben coefficients are available calibration proceeds using these. The raw counts are converted to equivalent Reflectance using:

$$r_i(l, c) = 100 \times \pi \times d_s^{\,2} \times \alpha_i \times \frac{\mathrm{CN}_i(l, c) - \mathrm{CN}_{0i}}{E_{\mathrm{si}} \times \cos[\vartheta(l, c)]} \quad \text{, for } i = 1,2$$

where

E_{si} = Equivalent solar irradiance,
α_i = Calibration coefficient for band i,
CN_{0i} = deep space digital count for band i,
and other terms are defined above.

6.12 Calibration of Thermal AVHRR channels

Extraction of in-flight calibration data

The in-flight calibration data for the IR channels consists of a space count, an internal calibration target count and three PRT temperatures for each scan line. The PRT temperatures are derived from 4 PRTs embedded in the sensor housing. The values from these sensors are time multiplexed, so for five consecutive scan lines one reads a sync, PRT1, PRT2, PRT3, PRT4 and then the pattern repeats. Three readings from each PRT are recorded and a majority count rule is used to decide the count used for the current scan line. If all three counts are different, the median (middle) value is used.

SeaShark then calculates one averaged slope and intercept pair per 50 scan lines and uses interpolated values for the intermediate values. This method reduces the effects of transient spikes.

6.12.1 Calculation of Spectral Radiance

We first calculate the at-sensor spectral radiances using the formula

$$L_i(l, c) = A_i(l) \times \mathrm{CN}_i(l, c) + B_i(l, c) \quad \text{, for } i = 3,4,5$$

where,
$A_i(l)$ = Slope value for band i line l
$B_i(l)$ = Intercept value for band i line l
$\mathrm{CN}_i(l, c)$ = digital count for the pixel at coordinates (l, c).

A non-linearity correction is then needed. If radiance correction terms are available the correction takes the form

$$\mathrm{RAD} = AR_{\mathrm{lin}} + BR_{\mathrm{lin}}^2 + C$$

where A, B and C are the correction coefficients and R_{lin} is the linear radiance calculated above. If these correction coefficients are unavailable a brightness correction method is used (explained below).

Brightness temperature is the weighted mean of the Planck function over the spectral response function of the channel. The spectral response functions for each channel are stored as a table in the detailed sensor configuration file for the satellite. SeaShark generates a brightness temperature to radiance look up table for each of the 3 IR channels (the resolution of this table is 0.1 K). SeaShark then searches the table for the radiance value and hence retrieves the corresponding brightness temperature. To speed the process the starting point in the search is set to the location which held the results for the previous pixel.

When radiance corrections are not available a brightness temperature correction is made. Tables of these corrections are available from NOAA. The table consists of a set of corrections which are proportional to the scene temperature and the internal target temperature. SeaShark looks up the correction using the pixel's temperature and PRT value and linearly interpolates within the table to find the correct value. If the scene temperature or the PRT temperature is outside the range of the table, the closest value in the table is used. Values are not extrapolated. The final results are scaled to fit into 16-bit words and written to the SHARP IMAGE file.

The difference in brightness temperatures calculated by SeaShark and it's predecessor SHARK are in the order of $\pm$ 0.1K.

For further information refer to the Sharp Level-2 User Guide, NOAA Technical Memorandum 107 Appendix B and subsequent amendments [39].

6.13 NOAA-KLM and the AVHRR/3 type instrument

SeaShark supports the new AVHRR/3 instrument which will be flown on the NOAA-K, L and M satellites. AVHRR/3 has a new 6th channel in the near-IR at 1.6μm. This will be referred to as 3A and will replace the 3B channel during the daylight part of the orbit. Another new feature of the instrument is the "split gains" for channels 1, 2 and 3A. This will, in effect, increase the sensitivity at low light levels, hence improving ice, snow and aerosol products. These new features can be easily accessed and customised through the appropriate SeaShark sensor configuration file.

There have been some slight changes to the level0 HRPT to incorporate the new features introduced by the AVHRR/3 instrument. Most importantly, a flag is present in each minor frame (word 7 Bit 10) indicating whether the scan line is from the 3A or 3B sensor. This enables SeaShark to adjust the handling and calibration procedures accordingly. The BAND_MODE field in the catalogue file reflects whether only 3A, 3B or both are present in the image.

In the detail sensor configuration file (for example NOAA-15.cfg) there is a master switch which informs SeaShark that this sensor is an AVHRR/3 type instrument:

```
NOAA-KLM_flag = Y;
```

It is advisable when you set the above flag that you also set the NOAA-KLM_format_IMAGE flag as this turns on the new features in the IMAGE file.

```
NOAA-KLM_format_IMAGE = Y;
```

It is also possible to set the NOAA-KLM_flag when the instrument is not an AVHRR/3 type instrument. This is not advised for normal processing, though the effects of defining multiple slope/intercepts for the visible channels can be interesting (one can easily threshold the raw

counts before calibration etc). Channel 3 will still be treated as an IR channel for AVHRR/2 type instruments.

6.13.1 NOAA-KLM calibration

SeaShark now uses a piece-wise function when calibrating channels 1, 2 and 3A. *N* ranges for this function can be defined in the sensor configuration file, for example:

```
channel1_calibration_ranges = 0 300 600 1024;
```

This defines three ranges, 0–299, 300–599 and 600–1023, and corresponding to these ranges must be slope and intercept values:

```
channel1_calibration_slopes = 0.12 0.15 0.17;
channel1_calibration_intercepts = 3.0 2.0 1.0;
```

Thus when calibrating channel 1, if a pixel has a count of 100 the slope and intercept values corresponding to the first range would be used, namely 0.12 and 3.0. The coefficients for Holben calibration are configured in a similar way. Ranges are defined but the time dependent coefficients are grouped together. A post-fixed number on the tag name indicates which range the values belong to. For example, defined in the NOAA-15.cfg file there would be something like:

```
Holben_dates = 01/08/1997 01/08/1998 01/08/1999 01/08/2000;
Holben_ranges = 0 500 1024;
```

Holben values for each of the above dates take the form: coefficient1 space_offset1 coefficient 2 space_offset2 coefficient3A space_offset3A.

```
Holben_values = 0.30 38.0 0.42 39.9 0.42 39.9 // Values for 01/08/97
                       0.30 37.9 0.43 39.3 0.42 39.9
                       0.30 37.8 0.45 39.1 0.42 39.9
                0.30 37.8 0.46 39.0 0.42 39.9; // Values for 01/08/2000
```

Note: holben values for 2nd range (500-1023 counts) are defined thus

```
Holben_values1 = 0.60 38.0 0.42 39.9 0.42 39.9 // Values for 01/08/97
                 0.63 37.9 0.43 39.3 0.42 39.9
                       0.68 37.8 0.45 39.1 0.42 39.9
                 0.71 37.8 0.46 39.0 0.42 39.9; // Values for 01/08/2000
```

The final configurable parameters which are needed are the integrated solar spectral irradiance and equivalent width of the spectral response function in micrometers. So like for channels 1 and 2 we need entries in the NOAA-15.cfg file

```
channel3_W = 0.246;
channel3_F = 254.19;
```

Note: at this time no calibration data exists for NOAA-K and the above values are just for demonstration purposes.

6.13.2 Changes to the IMAGE file

Extra calibration information for NOAA-K is now available in the image file FILE_DESCRIPTOR_RECORD. From byte 2001 the break points, slopes and intercepts are listed in the following format.

Break Point value 1 to *n* for band 1
Break Point value 1 to *n* for band 2
Break Point value 1 to *n* for band 3A

Slope Value for range 1 to *n* for band 1
Slope Value for range 1 to *n* for band 2
Slope Value for range 1 to *n* for band 3A

Intercept Value for range 1 to *n* for band 1
Intercept Value for range 1 to *n* for band 2
Intercept Value for range 1 to *n* for band 3A

Where *n* is the number of slope-intercept pairs defined in the SeaShark.cfg file. SeaShark will only write up to a maximum 1000 bytes of this data into the file. This means up to 27 preflight slope, intercept and break points per channel can be stored in the IMAGE file (far more than normally required).

A look up table for the calibration of channels 1, 2 and 3A has been added to the FILE_DESCRIPTOR_RECORD starting at byte 3013. The results in the look-up table are scaled into 16 bit words, these three scale factors and offsets are written in 6, 16 bit words (channel 1, 2, 3A scale factor, 1, 2, 3A offset) from byte 3001. The scale factors are configurable and are defined in the detailed sensor configuration file for the satellite. The values in the look up table can be helpful for approximate long hand calculations. The changed section in the FILE_DESCRIPTOR_RECORD is shown below.

No	Name	Short Description	Start byte	Stop byte	Size in bytes	Type
86		blanks	1109	2000	991	
87	calibration coefficients	calibration coefficients	2001	3001	1000	long
88		LUT scale factor for band 1	3001	3002	2	short
89		LUT scale factor for band 2	3003	3004	2	short
90		LUT scale factor for band 3A	3005	3006	2	short
91		LUT offset for band 1	3007	3008	2	short
92		LUT offset for band 2	3009	3010	2	short
93		LUT offset for band 3A	3011	3012	2	short
94	CH1 LUT	LUT for band 1	3013	5051	2048	unsigned short
95	CH2 LUT	LUT for band 2	5052	7100	2048	unsigned short
96	CH 3A LUT	LUT for band 3A	7101	9149	2048	unsigned short

Table 6-3 Extract from the (NOAA-KLM) FILE DESCRIPTOR RECORD

In the IMAGE_RECORD, the spare byte at position 24 in PREFIX_DATA is used to indicate which band, 3A or 3B, is active for a given scan line. A value of 0 (zero) represents 3B and a value of 1 (one) represents 3A. The SUF_DATA field has the slope and intercept fields set to zero for bands 1, 2 and 3, when 3A is active.

6.13.3 Changes to the LEADER file

In the SCENE_HEADER_RECORD, position 1413 (1800+1413 actual) gives the number of active bands (normally 5) and for NOAA-K processed data, where both 3A and 3B data is present, this will have the value 6.

6.14 SeaWiFS Distribution Products

SeaWiFS distribution products generated by SeaShark are similar in form to the AVHRR products discussed above.

CEOS L1A:
The L1A product contains uncalibrated data for all available channels.

CEOS L1B:
The L1B product contains calibrated data for all available channels.

CEOS L2:
L2 products contain atmospherically corrected radiances and geophysical products in a configurable combination [43], [44].

The algorithms used to generate the above products are discussed by the relevant design documentation [9]. They are based on libraries supplied with NASA's SeaDAS software, version 2.0, May 1996.[1] No changes were made to calibration or HDF libraries other than to correct coding errors – these are documented in the code itself.

6.15 Distribute

The files created in the Generate stage of processing are copied onto exabyte tape, except for Fast Delivery Products which are copied into the telecom.out directory. Refer to [9] for more information.

6.16 Delete

All files and directories associated with the product created are deleted from the disk.

1. SeaDAS software may be freely downloaded from NASA (`http://seadas.gsfc.nasa.gov`). Copyright is acknowledged.

7 COMPONENTS

7.1 Graphical User Interface

The GUI has been created using Sun WorkShop Visual 2.0, a software tool written specifically for the purpose of making the design and implementation of X-Motif graphical user interfaces easier. WorkShop Visual allows the creation of complex widget hierarchies through a graphical representation of the hierarchy, and allows the user to view the window immediately without having to compile any code first. The definitions of all the windows used in SeaShark are stored in a file named shark.xd which is generated by WorkShop Visual when the design is saved. The widget resources are stored in the Xdefaults.SeaShark file.

Each window in SeaShark has its own widget hierarchy, with the parent widget always being a shell widget. Shell widgets may be one of three types: a TopLevelShell, an ApplicationShell or a DialogueShell. There is only one ApplicationShell in SeaShark, the SeaShark Main Window, and all other windows are DialogShell windows which are children of the Main window. This means that the SeaShark application can only be iconised from the Main Window, as DialogShells lack the functionality to iconise themselves independently.

Some widgets perform functions when selected e.g. PushButton widgets and ToggleButton widgets. This functionality is accessed through a static callback function, the address of which is passed as a parameter during widget creation. Thus, the static function is called every time the widget receives an appropriate event from the X-Windows environment.

Most of the static callback functions are deliberately trivial, merely calling a class member function to do the real work. This allows the class definitions which control SeaShark functionality to remain encapsulated and separate from the classes which control the interface, thereby permitting a certain amount of parallel development. Furthermore, WorkShop Visual will generate C++ code which creates and initialises all the widgets defined in the graphical widget hierarchy. This includes stubs code, where the empty callback functions for every window in SeaShark are written to a single file. Obviously, having all the callback functions for all the windows in the one file could result in an unwieldy and confusing mess, so keeping this file simple is vital if the code is to be understood.

A separate C++ class exists for every window in SeaShark and each class definition forms a separate module (compilation unit). Separate classes exist to contain the static callback functions for each window and a simple naming convention has been adopted to indicate this e.g. the ZoomCallbacks_c class contains the static callback functions for the ZoomWindow_c class. All the class declarations are written to a header file which is generated by WorkShop Visual (shark.H). Each class has a “create” function which deals specifically with widget creation. These functions are written to another WorkShop Visual generated file (shark.cc), as is the “main” function and any code fragments which have been entered into WorkShop Visual directly. All other functionality is encapsulated in separate modules.

The “main” function initialises the X-Windows environment for the application and creates instances of every window class and callback class used in SeaShark. Finally, the program enters the polling loop for X-Windows applications and waits for the X-Server to supply appropriate X-Events to the SeaShark client when they occur e.g. when a PushButton widget is selected.

7.2 List of Modules

This chapter gives an overview of the modules which make up the SeaShark software. The overview is given as tables containing, for each module, its name and a brief description of its function. Modules are divided into the following types:

- *Processes*. These are physical design elements. They form the backbone or infrastructure of the SeaShark system and as such are only run as part of the SeaShark. They provide general functions.
- *Programs*. These are also the physical design elements. These are application programs in the classic which each provide a specific piece of functionality. The main difference between processes and programs is that the programs are standalone. They do not form part of the infrastructure and can in fact be run independently outside the SeaShark system and interface;
- *Classes*. These are the logical design elements which form the bulk of the SeaShark code. They are the fundamental building blocks which are the basis of SeaShark. They are libraries. They are called by the programs and processes to carry out the processing of SeaShark
- *Scripts*. These are support functions written, not in a general application programming language, but in operating system specific language.

7.2.1 Processes

A list of the SeaShark processes is given in Table 7-1.

Process Name	Description
SeaShark	SeaShark graphical user interface.
processor	Manages processing steps.
exabyte	Queues and actions requests to an exabyte tape drive.

Table 7-1 SeaShark Processes

7.2.2 Programs

A list of programs used by SeaShark is given in the Software User Manual [9].

In the standard SeaShark installation the source code for the programs is stored in $SEASHARKHOME/devsw/src/product/processing_steps. Some processing functions, for example archiving and retrieving, are implemented within the SeaShark (user interface) process.

7.2.3 Classes

A list of the classes used by SeaShark (excluding those from external packages) is given in Table 7-2. Further information is available in the source code header files.

Class Name	Description
AcqArchReportEntry	represents an acquisition and archive report entry.
AcqStnRank	represents the acquisition station priority order.
AffineCoefficients	represents a single sets of affine transformation coeficients that are used to transform from image row column to latitude and longitude (and vice versa).
AlgTestParameters	represents the L2 algorithm test parameters used to control output.
AncillaryAgent	supports ancillary data extraction for SeaWiFS L2.
AnglePoint	represents points defined by two angles (azimuth and elevation).
AnnotationData	represents the annotation data file generated for L1 and L2 products.
AnnotationDataFlex	represents the annotation data file generated for SeaWiFS L2.
AnnotationDataFlexReadOnly	a read-only representation of AnnotationDataFlex.
AQTIM	represents the AQTIM.DAT file of the SHARK system.
ArchiveBatchQueue	represents the archive batch queue.
ArchiveImmediateQueue	represents the archive immediate queue.
ArchiveMediaID	represents an archive label.
ArchiveQueue	handler for the archive queue.
AuxDataFile	represents a climatology or meteorology data file for SeaWiFS L2.
AuxFileName	defines an auxiliary data file name.
AuxQueryManager	base class controllong access to the auxiliary data files.
AVHRR_Channel	represents AVHRR channel 3 functionality for NOAA-KLM.
AVHRR_FDPData	represents an AVHRR Fast Delivery Product.
AVHRR_FDPText	stores descriptive information about the FDP.
AVHRRBackScan	represents AVHRR back scan data.
AVHRRCalibrationFields	represents AVHRR calibration data fields.
AVHRRChannelResponse	represents a table of AVHRR IR response versus wave number.
AVHRRHRPTImage	represents raw AVHRR HRPT image data.
AVHRRHRPTImageDLR	represents raw AVHRR HRPT image data in DLR format.
AVHRRHRPTImageDundee	represents raw AVHRR HRPT image data in Dundee format.
AVHRRHRPTImageNASA	represents raw AVHRR HRPT image data in NASA format.
AVHRRImportProduct	represents the AVHRR level 0 data in its lowest form.
AVHRRL2Algorithm	represents parameters and algorithms for AVHRR level 2 processing.
AVHRRLashamImage	provides I/O functionality for AVHRR lasham images (RAE format).
AVHRRLevel0Image	provides generic I/O and access to non instrument specific aspects of AVHRR Level0 images.
AVHRRLevel0Product	represents AVHRR level 0 products.
AVHRRLevel1Image	represents AVHRR level 1 images.
AVHRRLevel1Product	represents AVHRR level 1 products.
AVHRRSensor	common features of all AVHRR sensors.
AVHRRSharpImage	abstract base class representing AVHRR SHARP images.

Table 7-2 Classes Used by SeaShark

Class Name	Description
AVHRRSharp1Image	concrete class representation of AVHRR level 1 SHARP images.
AVHRRSharp2AImage	concrete class representation of AVHRR level 2A SHARP images.
AVHRRSharp2BImage	concrete class representation of AVHRR level 2B SHARP images.
AVHRRSpaceData	represents AVHRR space data within AVHRR images.
AVHRRTelemetry	represents the AVHRR telemetry fields within AVHRR images.
AVHRRTIPData	represents the AVHRR TIP data field within AVHRR images.
BatchCallbacks_c	X callback functions for the Batch Window of the GUI.
BatchQueue	handler for the batch queue.
BatchWindow_c	functionality associated with the Batch Window of the GUI.
BrouwerOrbitElements	abstract base class to represent mean brouwer orbital elements.
Buffer	provides buffering for device handlers.
BusyCursor	functionality for a generic busy cursor.
Calibration	represents the calibration component of the radiometric ancillary record of the SHARP level 2 leader file.
CalibrationCoefficients	represents a single set of slope/intercept values for converting AVHRR thermal infra red count values into radiances.
CalibrationData	represents the AVHRR calibration data in an AVHRR image.
CalibrationDataLine	represents the AVHRR calibration data for a single image line.
CalibrationFields	represents the AVHRR calibration data fields in an AVHRR image.
Canvas	functionality for the GUI display canvas.
Cat*xxxx*	The Cat*xxxx* classes describe parts of a Catalogue Entry. A Catalogue Entry is divided into a number of lines. The classes allow the reading and writing of the lines from and to a file. They also allow access to individual fields in a line . Details of the lines and fields in each line are given in Ref. [20] and Ref. [21].
Catalogue	the local archive of catalogue entries on disc. It provides functions for opening and closing the archive.
CatalogueEntry	an individual catalogue entry. It provides functions for reading and writing and searching for Catalogue Entries.
CatMetaLine1	the first meta data line of the catalogue entry format.
CatMetaLine2	the second meta data line of the catalogue entry format.
CatMetaLine3	the third meta data line of the catalogue entry format.
CatMetaLine4	the fourth meta data line of the catalogue entry format.
CatMetaLine5	the fifth meta data line of the catalogue entry format.
CCT	CCT access functions.
CEOS*xxxx*	describe different sections of a CEOS format file. The classes allow the reading and writing of CEOS sections from and to a file. The classes also allow access to individual fields in a CEOS section. Details of the CEOS formats can be found in Ref. [20] and Ref. [21].
CEOSAttitudeInfo	represents the satellite attitude information for SHARP CEOS products.
CEOSAVHRRHistogramData	represents histogram data for all five bands of an AVHRR image.
CEOSAVHRRSceneHeader	represents the scene header of SHARP products.
CEOSAVHRRSharpVolDirFile	represents the VDF of a SHARP product.
CEOSAVHRRSHRFramePar-ams	represents the frame parameters from the scene header record of an AVHRR CEOS product.

Table 7-2 Classes Used by SeaShark

Class Name	Description
CEOSAVHRRSHRMissionParams	represents the mission parameters from the scene header record of an AVHRR CEOS product.
CEOSAVHRRSHRProcessParams	represents the process parameters from the scene header record of an AVHRR CEOS product.
CEOSAVHRRSHRSensorParams	represents the sensor parameters from the scene header record of an AVHRR CEOS product.
CEOSAVHRRSHRSceneParams	represents the scene parameters from the scene header record of an AVHRR CEOS product.
CEOSBlankField	used to create variable length blank segments in the FDR
CEOSCalibration	represents calibration data (a slope and intercept) within the radiometric calibration record. Used internally by CEOSRadiometricAncillaryRec.
CEOSCorrectionInfo	represents orbit correction information for the orbit record of SHARP CEOS products.
CEOSFDRFixedSegment	represents the fixed segment at the beginning of a CEOS FDR.
CEOSFileDescriptor	represents the file descriptor information which appears at the beginning of all CEOS format files.
CEOSFileID	represents the record information parameters of a CEOS format file.
CEOSFlexFDR	represents the FDR for SeaWiFS L2 flexible format products.
CEOSGCPData	represents the GCP data of a SHARP CEOS product.
CEOSGCPRecord	represents the GCP record of a SHARP CEOS product.
CEOSGenericFilePtrRecord	represents the record information parameters of all CEOS format files.
CEOSGenericRecordID	base class for CEOS record IDs.
CEOSGenericTrailerRec	base class for CEOS trailer records.
CEOSHistogramData	represents histogram data for CEOS SHARP level 1 products.
CEOSHistogramRecord	represents histogram records for CEOS SHARP level 1 products.
CEOSImageParameters	represents the image parameters in the FDR of a SHARP image.
CEOSImageRecordID	represents the CEOS record ID of SHARP image records.
CEOSLevel1PixelDescription	represents the CEOS pixel description field for SHARP L1 FDRs.
CEOSLevel2PixelDescription	represents the CEOS pixel description field for SHARP L2 FDRs.
CEOSLevel1SharpImageVarSeg	represents the variable segment of a SHARP L1 CEOS image FDR.
CEOSLevel2SharpImageVarSeg	represents the variable segment of a SHARP L2 CEOS image FDR.
CEOSLINNDescription	represents the LINN description field of a SHARP L1 image FDR.
CEOSLocatorFields	represents the locator fields, part of the variable segment of FDRs.
CEOSMapProjectionData	represents the map projection data for SHARP CEOS products.
CEOSMapProjectionRecord	represents the map projection record for SHARP CEOS products.
CEOSMeanBrouwerElements	represents the mean Brouwer orbital elements for SHARP CEOS products.
CEOSNullVolDirFile	represents the NULL VDF of CEOS products.
CEOSOrbitParameters	represents the orbital parameters for a SHARP CEOS product.
CEOSOrbitRecord	represents the orbit record for a SHARP CEOS product.
CEOSOriginalTBUS	represents the original TBUS information in SHARP CEOS products.
CEOSOriginalTLE	represents the original TLE information in SHARP CEOS products.
CEOSParameter	represents a parameter within the radiometric ancillary record. Used internally by CEOSRadiometricAncillaryRec.
CEOSPixelGroupParameters	represents the pixel group parameters of a CEOS product.

Table 7-2 Classes Used by SeaShark

Class Name	Description
CEOSPrefixData	represents the image prefix data in every line of a SHARP CEOS image.
CEOSPrefixSuffixLocators	represents the prefix and suffix locator field, part of the SHARP image FDR.
CEOSProdDocInfo	represents the record information parameters of a CEOS format file.
CEOSProdIdInfo	represents the record information parameters of a CEOS format file.
CEOSProdIdVolNumberInfo	represents the record information parameters of CEOS files.
CEOSProduct	abstract base class for all CEOS products.
CEOSRadiometricAncillaryRec	represents the radiometric ancillary record of the SHARP Level 2 leader file Ref. [21].
CEOSRecordID	represents the record identification segment of CEOS products.
CEOSRecordInfoFields	represents the record fields of AVHRR SHARP FDRs.
CEOSRecordParameters	represents the record parameters of a SHARP CEOS product.
CEOSSatelliteInfo	represents the satellite information record which is part of the Leader file of the SeaWiFS LAC 1A distribution product.
CEOSSatelliteInfoL2	represents the satellite information for a level 2 CEOS product.
CEOSSeaWiFSAuxDataRecord	represents the auxiliary data record of a SeaWiFS flexible format CEOS product.
CEOSSeaWiFSCompIr-radRecord	represents the composite and irradiance record of a SeaWiFS flexible format CEOS product.
CEOSSeaWiFSGeophysParam-Record	represents the geophysical parameter record of a SeaWiFS flexible format CEOS product.
CEOSSeaWiFSL2LeaderFile	represents the leader file for a SeaWiFS level 2 CEOS product.
CEOSSeaWiFSLeaderFile	represents the leader file for a SeaWiFS CEOS product.
CEOSSeaWiFSSceneHeader	represents the scene header record for a SeaWiFS CEOS product.
CEOSSeaWiFSThreshCorrDa-taRecord	represents the thresholds and correction data records for a SeaWiFS flexible format CEOS product.
CEOSSeaWiFSVolDirFile	represents the VDF for a SeaWiFS CEOS product.
CEOSSequenceRecordID	represents a record ID which ends with a four byte ASCII field.
CEOSSharp1LeaderFile	represents the leader file for a SHARP level 1 CEOS product.
CEOSSharp2LeaderFile	represents the leader file for a SHARP level 2 CEOS product.
CEOSSharpLocatorVarSeg	represents the locator variable segment for SHARP CEOS products.
CEOSStateVectors	represents the state vector information for a SHARP CEOS product.
CEOSSuffixData	represents the suffix data for SHARP level 1 CEOS products.
CEOSTextRecord	represents the text record of a SHARP CEOS product VDF.
CEOSTiePointLocations	represents the tie point location fields in the annotation file of a SeaWiFS CEOS product.
CEOSTrailerFile	represents the trailer file of SHARP CEOS products.
CEOSVolDirFile	represents the volume directory file of the SHARP Level 1 and Level 2 formats.
CEOSVolumeDescriptorRec	a volume descriptor record of the SHARP Level 2 leader file Ref. [21].
CharStarArray	converts strings to char *[]'s, handling all the memory allocation for passing as an argv etc.
ClassifiedCatalogueEntry	represents mandatory or optional (classified) catalogue entries.
Cleanup	handles the removal of products.

Table 7-2 Classes Used by SeaShark

Class Name	Description
ClimatologyLoader	provides functionality to load climatology files into the SeaShark ancillary database.
CMDArg	an abstract base class which represents all the different forms of command line arguments to standalone programs.
CMDLineArguments	reads and interprets options given to standalone programs.
Coastline	represents coastline data extracted from the DCW that is associated with a particular SeaShark product.
CoastlineCoordinates	represents a point's geographical (lat/llon) and image (line/el) co-ordinates. Used internally by Coastline.
CoastlineSegment	coastline co-ordinates of an edge segment. Used internally by Coastline.
CombinedAtmosCorrn	represents atmospheric correction routines.
ConfigListRd	provides functionality to read a list of product types from a config file.
ConfigParamBase	contains the list of valid product types used by ConfigListRd.
ConfigReader	a file of configuration information. The class provides functions to open a configuration file, read an entry in the file, parse the entry and convert the entry to a numeric format.
ConfirmCallbacks_c	class encapsulating callback functions for the Confirm Window.
ConfirmWindow_c	functionality associated with the Confirm Window of the GUI.
ConvertToLine	converts start/stop latitude/longitude or time to start/stop line number.
Counter	counter which maintains state within a file.
CoverageList	represents temporal coverage by a series of passes.
DataLoader	base class for climatology and meteorology dataset loaders.
DCW*xxxx*	DCW*xxxx* classes describe components of the Digital Chart of the World (DCW), a database of geographical features used for annotation. Details of the DCW format can be found in Ref. [15], Ref. [16] and Ref. [17].
DCW	represents the DCW database.
DCWBrowse	represents the digital chart of the world.
DCWEdge	represents an edge (coastline, poltical boundary etc) within the DCW. Enables edges to be manipulated.
DCWFace	represents an face within the DCW. Enables faces to be manipulated.
DCWLibrary	represents a library wihtin the DCW. The DCW is structured as a number of libraries of which 4 are high resolution (NOAMER, EURNASIA, SOAMAFR, SASAUS) and one is a lowresolution library covering the whole earth.
DCWName	represents a name within the DCW. The DCW contains strings which are the names of other objects, such as files. This class handles the conversion of DCW names from DOS to UNIX format.
DCWTile	represents a tile within the DCW. Tiles make up the DCW libraries.
DCWVPFTable	represents a file in VPF format. All data in the DCW is stored in standard VPF format. This class allows access to VPF files.
DeviceHandler	abstract base class for device handlers.
DeviceKernel	provides functionality for device handlers.
DeviceMessageEntry	used internally to store connection information.
Dir	provides directory handling functionality.
DirectoryProduct	represents products which hold their data in a product directory.

Table 7-2 Classes Used by SeaShark

Class Name	Description
DirEntry	represents directory information for use by Dir.
DisplayCallbacks_c	a class encapsulating callback functions used by the Display Window.
DisplayProduct	represents displayable products.
DisplayWindow_c	functionality associated with the Display Window of the GUI.
DisplayWindow_d	encapsulated data associated with the Display Window.
DistnSeaWiFSImage	abstract base class for SeaWiFS distribution product image files.
DistnSeaWiFSImage1A	represents SeaWiFS level 1A image files.
DistnSeaWiFSImage1B	represents SeaWiFS level 1B image files.
DistnSeaWiFSImage2A	represents SeaWiFS level 2A image files.
DistnSeaWiFSImage2B	represents SeaWiFS level 1B image files.
DistnSeaWiFSImage2Flex	represents SeaWiFS level 2 flexible format image files.
DistributeBatchQueue	represents the distribute batch queue.
DistributeImmediateQueue	represents the distribute immediate queue.
DistributeQueue	handler for the distribute queue.
DistributionReportEntry	a report entry containing details of a product which has been distributed.
EarthLocationPoint	represents a position on the Earth.
EarthRectangle	represents rectangular regions of the globe.
ECEFElements	represents Earth Centred Earth Fixed orbit data elements.
ECIElements	represents Earth Centred Inertial orbit data elements.
ErrorStatus	general purpose error handling class for storing error status and error strings.
ErrorWindow_c	functionality associated with the Error Window of the GUI.
ESAOrder	a user request originating from ESRIN User Services.
ESAOrderElement	base class containing common functionality for order classes.
ESAStationName	contains ESA processing and acquistion station names in all there formats used by SeaShark.
Exabyte	Exabyte access functions.
ExabyteKernel	Interface to the device handler for the exabyte.
FastDeliveryProduct	represents a fast delivery product.
FDP_Bounding	handles the calculation of FDP corners.
FDP_pixel_Bounding	handles mercator projection corner point calculation for FDPs.
FDP_stereo_Bounding	handles stereographic projection corner point calculation for FDPs.
FDPCodes	represents the special pixel codes used in FDP image data.
FDPConsts	encapsulates constant definitions for FDPs.
FDPData	represents FDP image data.
FDPImage	provides display functionality for a fast delivery product.
FDPProjection	encapsulates FDP projection choice.
FDPText	represents the text description of an FDP.
FieldPos	represents a field within an order file.
FlagCMDArg	used internally by CmdArg.
ForwardTransformCoefficients	used internally by TransformCoefficients.
GenImage	abstract base class for images without bit unpacking.

Table 7-2 Classes Used by SeaShark

Class Name	Description
GUI*xxxx*	contain global classes used by SeaShark. They are declared in the interface and are all used internally by SeaSharkGlobals. This guarantees their order of construction and destruction.
GUI_Display	low level Display Window functionality.
GUICatalogue	provides global access to the catalogue store.
GUIConfig	provides global access to SeaShark.cfg
GUIImportMonitor	provides global access to functionalty to monitor product import.
GUIImportTimer	provides the timer used for updating the interface and checking directories, such as the import directory.
GUIMessageStore	provides message handling facilities used for socket communication.
GUIObjectStore	provides object handling facilities.
GUIReports	provides report handling facilities.
GUITaskMonitor	provides global access to functionality to monitor tasks.
GifImage	represents an image in standard GIF format. The class provides functions for reading and writing an image and for accessing associated information such as the image's colour table.
Histogram_c	represents histograms of any parameterised type.
HistogramCallbacks_c	class encapsulating callback functions for the Histogram Window.
HistogramEntry	used internally by Histogram.
HistogramWindow_c	functionality associated with the Histogram Window of the GUI.
HistogramWindowData	represents the internal state of the Histogram Window.
HolbenData	contains the Holben values for AVHRR leve 2 processing.
HolbenTable	contains the set of Holben data for a given sensor.
HRPT*xxxx*	describe different parts of HRPT format files. The classes allow the reading and writing of sections of a n HRPT scan line. The classes also allow access to individual fields in a section. Details of the HRPT formats can be found in section 5.
HRPT_types	abstract base class for classes representing different HRPT formats.
HRPTAuxilliarySync	represents the auxilliary sync field which is at the end of HRPT minor frames within a HRPT image.
HRPTFrameSync	represents the frame sync field which is at the start of HRPT minor frames.
HRPTImage	represents common aspects of all HRPT images. Handles generic I/O and access to non instrument specific aspects of HRPT images.
HRPTImageSummary	represents the first quality check information and other summary information about an HRPT file which is used though the SeaShark processing chain.
HRPTLineStatus	denotes the status of a line in a HRPT image, i.e. good, bad, missing etc.
HRPTSpacecraftID	represents the Spacecraft ID field which is common to all HRPT images. The field identifies which satellite the data is from and also the HRPT minor frame number of the current HRPT major frame.
HRPTTimeTag	represents the time tag field which is common to all HRPT images. The field defines the current day number (Julian) and the time in milliseconds since midnight of the first byte of HRPT minor frame.
HumidityClimDataLoader	functionality to ingest humidity climate data files into SeaShark.
HumidityMetDataLoader	functionality to ingest humidity meteorology data files into SeaShark.
HumidityQueryManager	functionality to interrogate the humidity data in the ancillary database.

Table 7-2 Classes Used by SeaShark

Class Name	Description
IEFCatalogueUpdate	represents IEF catalogue batch update file.
IEFHeader	represents the IEF catalogue header data.
IEFTrailer	represents the IEF catalogue trailer.
Image	top level level class of all the images that are either generated or accessed within the SeaShark application.
ImageAverage	represents an averaged image parameter from a sequence of consecutive image scan lines.
ImageDisplayRect	represents a rectangular area of a displayed image.
ImageGridDimensions	represents the specification of the size (width, height, spacing, etc) of a grid of data associated with an image.
ImageLineStatus	indicates the quality of a particular image scan line.
ImageSummary	top level class that of all objects which in some way summarises details about an image.
ImportCheck	used to ensure files in telecom.in/orders are fully written before import.
ImportProduct	abstract base class for import products.
ImportSeaWiFSProduct	represents the SeaWiFS level 0 data as presented to the SeaShark application from the HRPT frame formatter.
InitWindow_c	functionality associated with the Initialisation Window.
InitWindowCallbacks_c	class encapsulating callback functions for the Initialisation Window.
InteractiveCallbacks_c	class encapsulating callback functions for the Interactive Control Window of the GUI.
InteractiveControls_c	functionality associated with the Interactive Control Window.
InterSlope	contains value pairs and provides manipulation functions.
IntervalCounter	counter which maintains state within a file.
IRData	contains parameters and tables for calibration of AVHRR IR bands.
KeyRange	allows ranges of keys to be specified for use with ResourceManager.
LandSeaMask	represents the the land sea mask data that is generated during the SeaShark product processing chain from the Digital Chart of the World.
LatLongToLine	converts latitude/longitude to start/stop line number.
Level0Product	represents level 0 products of either AVHRR or SeaWiFS.
Level1Product	represents level 1 products of either AVHRR or SeaWiFS.
Level1ArchiveImage	represents level 1 images in archive format.
LevelTwoFlags	provides routines to set flag values for SeaWiFS level 2 products.
Line	represents lines.
LUTReader	look-up-table reader for SeaWiFS level 2 products.
MainCallbacks_c	X callback functions for the Main Window of the GUI.
MainWindow_c	functionality associated with the Main Window of the GUI.
ManditoryCMDArg	used internally by CmdArg.
MapTransform	provides functionality for image/map projection.
MeanOrbitalElement	represents the mean orbital element information in a CEOS leader file.
MediaReportEntry	represents a media report entry.
MediaToolCallbacks_c	X callback functions for the Media Tool Window of the GUI.
MediaToolWindow_c	functionality associated with the Media Tool Window of the GUI.
MediaToolWindowData	represents the internal state of the Media Tool window.

Table 7-2 Classes Used by SeaShark

Class Name	Description
Message	handles low level socket messaging.
MessageWindow_c	functionality associated with the Message Window of the GUI.
MeteorologyLoader	provides functionality to load meteorology files into the SeaShark ancillary database.
Monitor	used to call an external monitoring program.
MotifList	functionality to handle Motif list widgets.
MTHandler	provides access to the magnetic tape.
MTIO	common features of all tape access.
Navigation	abstract base class
NavigationData	represents the navigation data within the SeaShark products, i.e. a grid of points within a product's image for which the location, sun and satellite angles are stored. The also has operators to get the location or sun and satellite for any pixel in the corresponing image.
NavigationDataSlicer	allows buffered access to data in the navigation grid.
NPointInterpolation	generates linearly interpolated values.
OceanFDP	level 2 processing for SeaWiFS FDPs.
OceanL2A	processing for SeaWiFS level 2A products.
OceanL2B	processing for SeaWiFS level 2B products.
OceanLevel2	processing for SeaWiFS level 2 products.
OperationReportEntry	a report entry containing details of an operation which has been carried out.
OptionalCMDArg	used internally by CmdArg.
OptionsWindow_c	functionality associated with the Options Window of the GUI.
OrbitDataMgr	handles the SeaShark TBUS and TLE archive which is stored on disc. The physical storage mechanism is encapsulated and hidden from users of the class.
OrbitStitchConfig	represents the config file for the orbit-stitching process.
Order	reads orders, requests for a specified product to be generated by an acquisition station, received from ESRIN.
OrderFormCallbacks_c	class encapsulating callback functions for the Order Form Window.
OrderFormWindow_c	functionality associated with the Order Form Window of the GUI.
OrderHandler	handles the import and moving of order files.
OrderStatusEntry	represents an entry in an order status file.
OrderStatusFile	represents an order status file.
OverlayCallbacks_c	class encapsulating callback functions for the Overlay Window.
OverlayMask	handles display masks e.g. land sea mask and coastline.
OverlayWindow_c	functionality associated with the Overlay Window of the GUI.
OzoneClimDataLoader	functionality to ingest ozone climate data files into SeaShark.
OzoneMetDataLoader	functionality to ingest ozone meteorology data files into SeaShark.
OzoneQueryManager	functionality to interrogate the ozone data in the ancillary database.
Parameter	represents parameters in the radiometric ancillary recordof the SHARP level 2 leader file.
PARTable	PAR library functions.
PassCoverage	represents temporal coverage by a series of passes.
PlaceHolder	inline template class to hold data to be read from or written to a file.

Table 7-2 Classes Used by SeaShark

Class Name	Description
Point	represents the mathematical concept of a point which is used in many places in SeaShark, for example in navigation
PointCallbacks_c	class encapsulating callback functions for the Point Window.
PointWindow_c	functionality associated with the Point Window of the GUI.
PostscriptFilter	used to generate postscript quicklook files.
PressureClimDataLoader	functionality to ingest pressure climate data files into SeaShark.
PressureMetDataLoader	functionality to ingest pressure meteorology data files into SeaShark.
PressureQueryManager	functionality to interrogate the pressure data in the ancillary database.
PrimaryWindow	functionality to handle lists of tasks in a Window.
ProcessBatchQueue	represents the process batch queue.
ProcessCallbacks_c	X callback functions for the Process Window of the GUI.
ProcessImmediateQueue	represents the process immediate queue.
ProcessingCommand	combines UnixCommand and ConfigReader classes to facilitate execution of processing commands.
ProcessorHandler	handles communication with the processor binary.
ProcessorKernel	functionality for the processor binary.
ProcessorQueue	handler for the processor queue.
ProcessWindow_c	functionality associated with the Process Window of the GUI.
Product	top level level class of all the product that are either generated or accessed within the SeaShark application
ProductID	represents product identifiers which have a SeaShark standard format.
ProductOrder	represents an ESA product order.
ProductTypeData	handles lists of PushButton widgets for use in cascade menus.
PRTCountToTempCoeffs	represents the NOAA table of coefficients for black body parameters.
PSPoint	handles DCW clipping for postscript quicklook generation.
QIC	QIC access functions.
QueueHandler	abstract base class for queue handlers.
RAEHeaderFile	represents RAE tape format header file.
RawImage	represents simple, raw binary image files with no header.
Rectangle	represents the mathematical concept of a rectangle which is used in many places in SeaShark, for example in navigation.
ReportEntry	common features of report entries.
Report	provides functions for handling the various SeaShark reports, including the reading, formatting and writing of reports etc.
ReportCallbacks_c	X callback functions for the Report Window of the GUI.
ReportHandler	handles report generation.
ReportWindow_c	functionality associated with the Report Window of the GUI.
ResourceManager	provides generic storage mechanism in a directory structure defined by a set of keys.
ResourceManager1Key	a resource manager which uses one key to differentiate between esources. The key provides the file name in which to store the resource.
ResourceManager2Key	a resource manager which uses two keys to differentiate between resources. Key 1 = directory name, key 2 = file name. Used internally by ResourceManager.

Table 7-2 Classes Used by SeaShark

Class Name	Description
ResourceManager3Key	a resource manager which uses three keys to differentiate between resources. Key 1 = directory name, key 2 = sub-directory name, Key 3 = file name. Used internally by ResourceManager.
ResourceManager4Key	a resource manager which uses four keys to differentiate between resources. Key 1 = directory name, key 2/3 = sub-directory name, Key 4 = file name. Used internally by ResourceManager.
ResourceManager5Key	a resource manager which uses five keys to differentiate between resources. Key 1 = directory name, key 2/3/4 = sub-directory name, Key 5= file name. Used internally by ResourceManager.
RetrieveCallbacks_c	class encapsulating callback functions for the Retrieve Window.
RetrieveBatchQueue	handles the retrieve batch queue.
RetrieveDialog_c	functionality associated with the Retrieve Dialog Window of the GUI.
RetrieveImmediateQueue	handles the retrieve immediate queue.
RetrieveQueue	handler for the retrieve queue.
ReverseTransformCoefficients	used internally by TransformCoefficients.
RRemove	provides a recursive move facility.
SatelliteOrbitData	purely virtual top level class which represents satellite orbit data in all it's different forms (eg: two line elemnt, tbus, etc).
ScanLineBuffer	represents a scan line of image data
ScanLineField	represent a scan line of image data.
SeaAtmosCorrection	PML atmospheric correction for SeaWiFS level 2 products.
SeaSharkBase	base class for device handlers.
SeaSharkConstants	contains all the useful constant values that SeaShark uses (such as the raduis of the earth and π).
SeaSharkFile	extends RWFile to detect disc full over NFS.
SeaSharkGlobals	contain global classes used by SeaShark
SeaSharkMessage	provides low level messaging capability.
SeaSharkTime	repesents time, down to units of milliseconds, as required by SeaShark.
SeaWIFS*xxxx*	describe different parts of SeaWIFS format files. The classes allow the reading and writing of sections of a n SeaWiFS scan line. The classes also allow access to individual fields in a section. Details of the SeaWiFS formats can be found in [38] and [40].
SeaWiFS_L2A_Algorithm	encapsulates processing algorithms for SeaWiFS level 2A products.
SeaWiFS_L2B_Algorithm	encapsulates processing algorithms for SeaWiFS level 2B products.
SeaWiFS_L2C_Algorithm	encapsulates processing algorithms for SeaWiFS level 2C products.
SeaWiFS_L2FDP_Algorithm	encapsulates processing algorithms for SeaWiFS level 2 FDPs.
SeaWiFS_L2Flex_Algorithm	encapsulates processing algorithms for SeaWiFS flexible format products.
SeaWiFSCalibration	encapsulates SeaWiFS calibration for CEOS products.
SeaWiFSDistributionProduct	base class for SeaWiFS distribution products.
SeaWiFS_FDPData	stores information about a SeaWiFS FDP image.
SeaWiFS_FDPText	supplies SeaWiFS specific parameters to the FDP text file.
SeaWiFSDarkRestorePixel	used internally by SeaWiFSSyncPixels.
SeaWiFSGainAndTDI	represents the field from the SeaWiFS HRPT Image which contains data about the instrument Gain and TDI. It it is not currently used but will be required in the future.

Table 7-2 Classes Used by SeaShark

Class Name	Description
SeaWiFSGPSOrbitData	represents the field from the SeaWiFS HRPT Image which contains orbit information derived from the GPS on the platform.
SeaWiFSGPSQA	holds QA parameters for SeaWiFS GPS and attitude telemetry checks.
SeaWiFSGPSValues	holds GPS values from the SeaWiFS telemetry.
SeaWiFSHRPTImage	provides I/O and access to SeaWiFS-dependent aspects of SeaWiFS HRPT Images.
SeaWiFSImportProduct	represents the SeaWiFS level 0 data as presented to the SeaShark application from the HRPT frame formatter.
SeaWiFSInstrInfo	holds SeaWiFS instrument information for CEOS leader files.
SeaWiFSInstrTelemetry	represents the field from the SeaWiFS HRPT Image which contains data about the instrument state. Not currently used but will be required in the future.
SeaWiFSL1DistProduct	represents a SeaWiFS level 1 distribution product.
SeaWiFSL2Algorithm	encapsulates processing algorithms for SeaWiFS L2A, L2B and FDP.
SeaWiFSL2DistProduct	represents a SeaWiFS level 2 distribution product.
SeaWiFSL2FlexProduct	represents a SeaWiFS level 2 flexible format CEOS product.
SeaWiFSLAC1AProduct	represents a SeaWiFS level 1A CEOS product.
SeaWiFSLAC1BProduct	represents a SeaWiFS level 1B CEOS product.
SeaWiFSLAC2AProduct	represents a SeaWiFS level 2A CEOS product.
SeaWiFSLAC2BProduct	represents a SeaWiFS level 2B CEOS product.
SeaWiFSLevel0Product	represents a SeaWiFS level 0 product.
SeaWiFSLevel1Image	definition of the level 1 SeaWiFS image data format within the SeaShark application.
SeaWiFSLevel1Product	represents the SeaWiFS data after it has been processed to level 1 product. It provides functionality for Fast Delivery Product generation.
SeaWiFSLineInterface	provides a simple interface for processing level 2 data.
SeaWiFSPixelField	used internally by SeaWiFSSyncPixels.
SeaWiFSStartSyncPixel	used internally by SeaWiFSSyncPixels.
SeaWiFSStopSyncPixel	used internally by SeaWiFSSyncPixels.
SeaWiFSSyncPixels	represents the pixel field from the SeaWiFS HRPT Image and the SeaWIFS Level 1 image.
SeaWiFSRawProduct	represents the SeaWiFS data after it has been imported and is ready for processing through to a full level 1 product.
Sensor	common features of all sensors.
SHARK_Consumer_Base	base class for socket handlers.
SHARK_Inet_Sock	generic internet socket class.
SharpCalibrationFields	represents the SHARP calibration data fields.
SharpLevel1Product	represents a SHARP level 1 product.
SharpLevel2AProduct	represents a SHARP level 2A product.
SharpLevel2BProduct	represents a SHARP level 2B product.
SharpLevel2Product	represents a SHARP level 2 product.
SharpProduct	abstract base class for SHARP CEOS products.
SharpVarSeg	represents the variable segment in a SHARP FDR.

Table 7-2 Classes Used by SeaShark

Class Name	Description
SpacecraftSOH	represents the spacecraft state-of-health data that is included in the SeaWiFS HRPT data stream and the imagery file of the SeaWiFS level 1 archive and CEOS distribution products. Not currently used but will be required in the future.
Station	represents an aquisition station.
StringDB	associates a string key with an object for use with an object database.
SunEarthGeometry	represents the geometry of the Sun and the Earth at a given time.
SunRasterImage	represents a rasterfile for quicklook images.
SW_FrameFormatted	represents a SeaWiFS frame formatted HRPT image.
SW_Raw10BitHRPT	represents a SeaWiFS 10 bit formatted HRPT image.
Task	represents the task concept within SeaShark.
TaskCallbacks_c	X callback functions for the Task Window of the GUI.
TaskForm	stores detailed information for a given task.
TaskFormCallbacks_c	X callback functions for the Task Form Window of the GUI
TaskFormWindow_c	functionality associated with the Task Form Window of the GUI.
TaskPool	stores the list of tasks on the SeaShark system, grouped by sensor.
TaskQueueStore	abstract base class for task queues.
TaskWindow_c	functionality associated with the Task Window of the GUI.
TBUS	The TBUS*xxxx* classes describe parts of a TBUS message which provides orbital information for NOAA satellites. A TBUS message is divided into a number of parts, of which the Part 4 is relevant to SeaShark. The Part 4 contains a number of lines. The classes allow the reading and writing of the lines from and to a file. They also allow access to individual fields in a line . Details of the lines and fields in each line are given in Ref. [20] and Ref. [21].
TBUSLine	the common parts of all lines of the TBUS Part 4.
TBUSLine1	the first line of the TBUS Part 4.
TBUSLine2	the second line of the TBUS Part 4.
TBUSLine3	the third line of the TBUS Part 4.
TBUSLine4	the fourth line of the TBUS Part 4.
TBUSLine5	the fifth line of the TBUS Part 4.
TextCallbacks_c	X callback functions for the Text Window of the GUI.
TextField	handles status bars on windows.
TextWindow_c	functionality associated with the Text Window of the GUI.
TimerOptionsCallbacks_c	X callback functions for the Tmer Options Window of the GUI.
TimerOptionsWindow_c	functionality associated with the Timer Options Window of the GUI.
TimeToLine	converts a given time to an image scan line number.
TLE	The TLE (Two Line Element) contains orbital information for SeaStar satellites. It is divided into a number of lines.
TLELine1	the first line of the Two Line Element.
TLELine2	the second line of the Two Line Element.
Token	used to encapsulate messages to be sent via sockets.
TransformCoefficients	represents the collection of coordinate transformation coefficient which are used to convert between image row and column and latitude and longitude and vice versa in SeaShark navigated products.

Table 7-2 Classes Used by SeaShark

Class Name	Description
TwoDBitMask	represents two dimensional bit masks within the SeaShark application.
TwoLineElement	represents orbit information supplied in TLE format.
UnixCommand	represents, constructs and executes unix commands from within a program.
UnixDir	represents unix directories for both files and directories.
UnixDirectoryList	generates list of file and or directories within a given unix directory.
UnixPath	represents unix path names for both files and directories.
VPFTable	represents VPF tables used by the DCW database.
WarningWindow_c	functionality associated with the Warning Window of the GUI.
WindClimDataLoader	functionality to ingest windspeed climate data files into SeaShark.
WindMetDataLoader	functionality to ingest windspeed meteorology data files into SeaShark.
WindspeedQueryManager	functionality to interrogate the windspeed data in the ancillary database.
WorkingWindow_c	functionality associated with the Working Window of the GUI.
ZoomCallbacks_c	class encapsulating callback functions for the Zoom Window.
ZoomWindow_c	functionality associated with the Zoom Window of the GUI.

Table 7-2 Classes Used by SeaShark

7.3 Scripts

A list of scripts used in SeaShark. For further details see section 7.6 on page 106.

Script name	Description
CleanDataAreas	Cleans data directory.
CreateInstallTape	Creates a tar file containing files necessary for a SeaShark installation. Copies files from the current installation.
Install	Unpacks an installation tape.
SeaSharkBuildDir	Creates SeaShark directory structure.
SeaSharkBuildComms	Creates SeaShark communication files.
TidySeaShark	Removes RCS files, object files, testfn directories and libraries from the src directory of a SeaShark installation. Used before CreateInstallTape.

Table 7-3 Scripts used by SeaShark

7.4 Processes

7.4.1 Media Handler

The media handler is an event driven process spawned by the graphical user interface (GUI) process. All archive and distribution requests are sent via socket connection to the media handler. Each I/O request is in the form of a list of products. Other requests include status, directory and device manipulation requests such as eject media.

7.4.1.1 Process Execution

STEP 1. Initialisation. During initialisation the process reads a configuration file called MediaHandler.cfg and connects to the predefined GUI process socket. For each device specified in the configuration file, a device handler process is initialised. Once communication has been

established with these processes, the media handler sleeps awaiting a message from the GUI Process.

STEP 2. Request Handling. When a message is received on the socket from the GUI process, the media handler parses the requests and sends the appropriate message to the device handler. For each connection, the media handler maintains a queue of requests. When requests are completed they are removed from the queue and their status is returned to the GUI.

STEP 3. Termination. If the GUI is shut down a message is received to exit. During the exit phase, the current request on each of the devices is completed and each queue is saved. The same actions are taken if the socket connection to the GUI is broken.

7.4.1.2 Requests

Each request will contain: a device name; a request type which consists of the standard device operations such as read, write or retrieve status; and a list of products.

Typical requests will be processed and split into lists of files to be send to the device handlers.

Socket messages will be sent in packets which will be handled by a Packet class. The structure

Description	Request ID	Device Type	Device Name	Request Type	Request Argument	Number of Products	Product	…
Bytes	10	1	20	2	50	2	14	

Table 7-4 Request Structure

of the request is shown in Table 7-4 and a brief description of the fields follows:

- **Request ID** is a unique number for each request structure which is sent on each socket.
- **Device Type** can be one of the following supported devices:
  - 0 – Optical Disk
  - 1 – Exabyte
- **Device Name** is the alias given to the device from the configuration file. From this alias the media handler can obtain the device special file and the number of products that can be placed on the device.
- **Request Type** details the type of work the device is to undertake:
  - 0 – Reset
  - 1 – Read
  - 2 – Write
  - 3 – Get Status
  - 4 – Get Directory
  - 5 – Eject
  - 6 – Stop
  - 7 – Rewind
  - 8 – Forward
  - 9 – Forward Skip File
  - 10 – Backward Skip File

  - 11 – Format
  - 12 – Returned Status
  - 13 – Returned Directory Entry
- **Request Argument** is message specific.
- **Number of Products** is the number of product ID's to follow.
- **Product ID** is the standard product ID. The product will be found either on the specified device during read operations or in the archive of the distribute directory during write operations.

7.5 Programs

In this section, the internal workings of some of the binaries are briefly described. Further information on how to use the binaries, including those not mentioned here, can be found in [10].

7.5.1 Ingest_Climatology

Reads raw climatology data in COADS (ASCII) format or TOMS (binary) format and processes it into SeaShark Auxiliary Database format for use in SeaWiFS level 2 processing. Interpolation is used to fill in any holes in the data for the given area of coverage (no extrapolation is performed for data points lying outside the area of coverage). Interpolation is performed (specified via command line argument) as follows: the average value of the real data points is calculated and assigned to each of the missing data points; an iterative process is then applied to each missing data point to smooth the interpolation: the value of a missing data point is calculated as the average of its immediate neighbours, providing they themselves are real data points (immediate neighbours are defined as the eight points surrounding a point in a regular matrix of data points); if an immediate neighbour is missing, or now has a value gained through interpolation, it is not included in the calculation of the average value. The number of iterations of the interpolation process can be controlled via a command line argument.

7.5.2 Ingest_Meteorology

Reads raw meteorology data in ECMWF (binary) database format or TOMS (ASCII) format and processes it into SeaShark Auxiliary Database format for use in SeaWiFS level 2 processing. Interpolation is applied in the same manner as described for Ingest_Climatology.

7.6 Scripts

In this section each script is described.

7.6.1 CleanDataAreas

Recursively removes files from the data directory. Checks that the SEASHARKHOME environment variable is defined and prompts for confirmation before removing files. It is assumed that the data directory is located at $SEASHARKHOME/data. Files are removed from the following directories: tasks, products, orders, reports, telecom.in, telecom.out, catalogue and tapes.

7.6.2 CreateInstallTape

Copies a working version of SeaShark to tape, with or without source code. Checks that the SEASHARKHOME environment variable is defined and echos this to the shell. Prompts the user, to determine if source code is required on the tape. Rewinds the tape and then uses the UNIX tar command to copy files from the following directories: install, bin, help, qasw, data/DCW, data/orbit_data, data/ancillary, config, verify, and if source code is required, lib, src, include, Makefile, SeaDAS, OceanColourF77, PROJ.4, Xpm and doc.

7.6.3 Install

Unpacks a SeaShark installation tape to the location pointed to by the SEASHARKHOME environment variable. Checks that $SEASHARKHOME is defined and prompts the user for confirmation that this and $TAPE are set correctly. Runs SeaSharkBuildDir and SeaSharkBuildComms. Prompts the user for permission to append the cshrc.SeaShark file to the existing $HOME/.cshrc file. Rewinds the tape and extracts the files.

7.6.4 SeaSharkBuildComms

Creates communication files for SeaShark i.e. *.sock files which define unique socket numbers for SeaShark to use for communication with spawned processes, like exabyte and processor.

7.6.5 SeaSharkBuildDir

Creates the complete directory structure required to contain all the files used by SeaShark. Checks that the SEASHARKHOME environment variable is defined and creates the directory structure at the location pointed to by SEASHARKHOME.

7.6.6 TidySeaShark

Removes unwanted files (used prior to the creation of an installation tape). Checks that the SEASHARKHOME environment variable is defined and prompts the user for confirmation. Removes testfn directories, RCS directories, Templates.DB directories, object files (*.o), library files (*.a) and hidden .make.* files.

7.6.7 cshrc.SeaShark

Defines the following environment variables: SEASHARKHOME, SEASHARKDATA, SEASHARKCONFIGFILE, SEASHARKTELECOMIN, SEASHARKTELECOMOUT, QASW_IDL, QASW_DATA and DOROEXEC. Adds the $SEASHARKHOME/bin directory to $path so that the executables can be found.

Appendix A SOURCE DIRECTORY STRUCTURE AND DESCRIPTION

A.1 Class interconnection

In the following section are a selection of diagrams showing the interconnection between class in SeaShark.

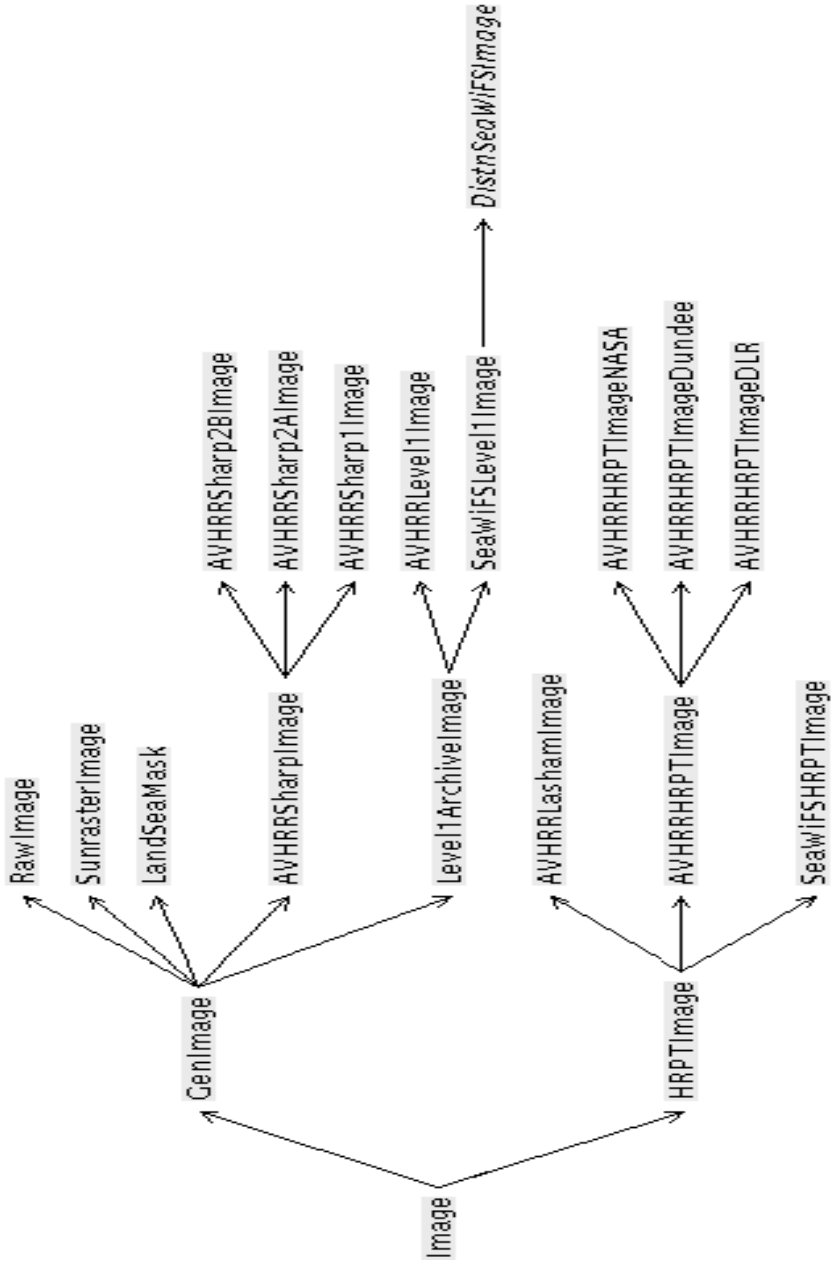


Figure A-1 Image hierarchy

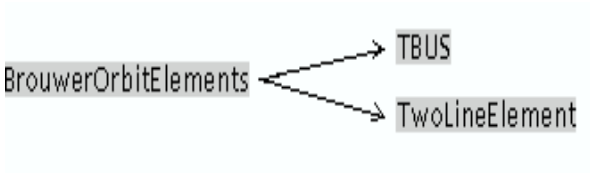


Figure A-2 BrouwerOrbitElement hierarchy

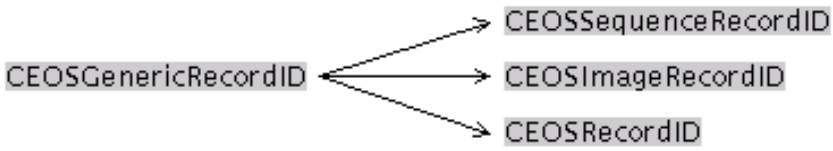


Figure A-3 CEOSGenericRecordID hierarchy

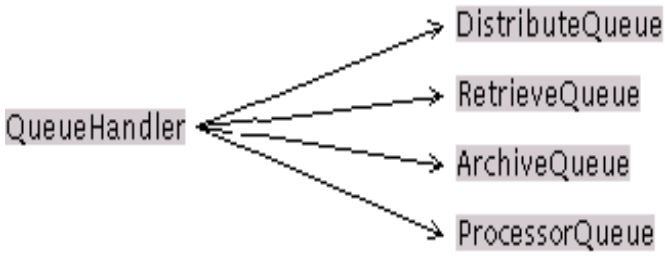


Figure A-4 QueueHandler hierarchy

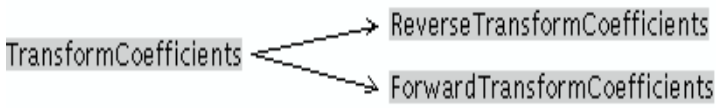


Figure A-5 TransformCoefficients hierarchy

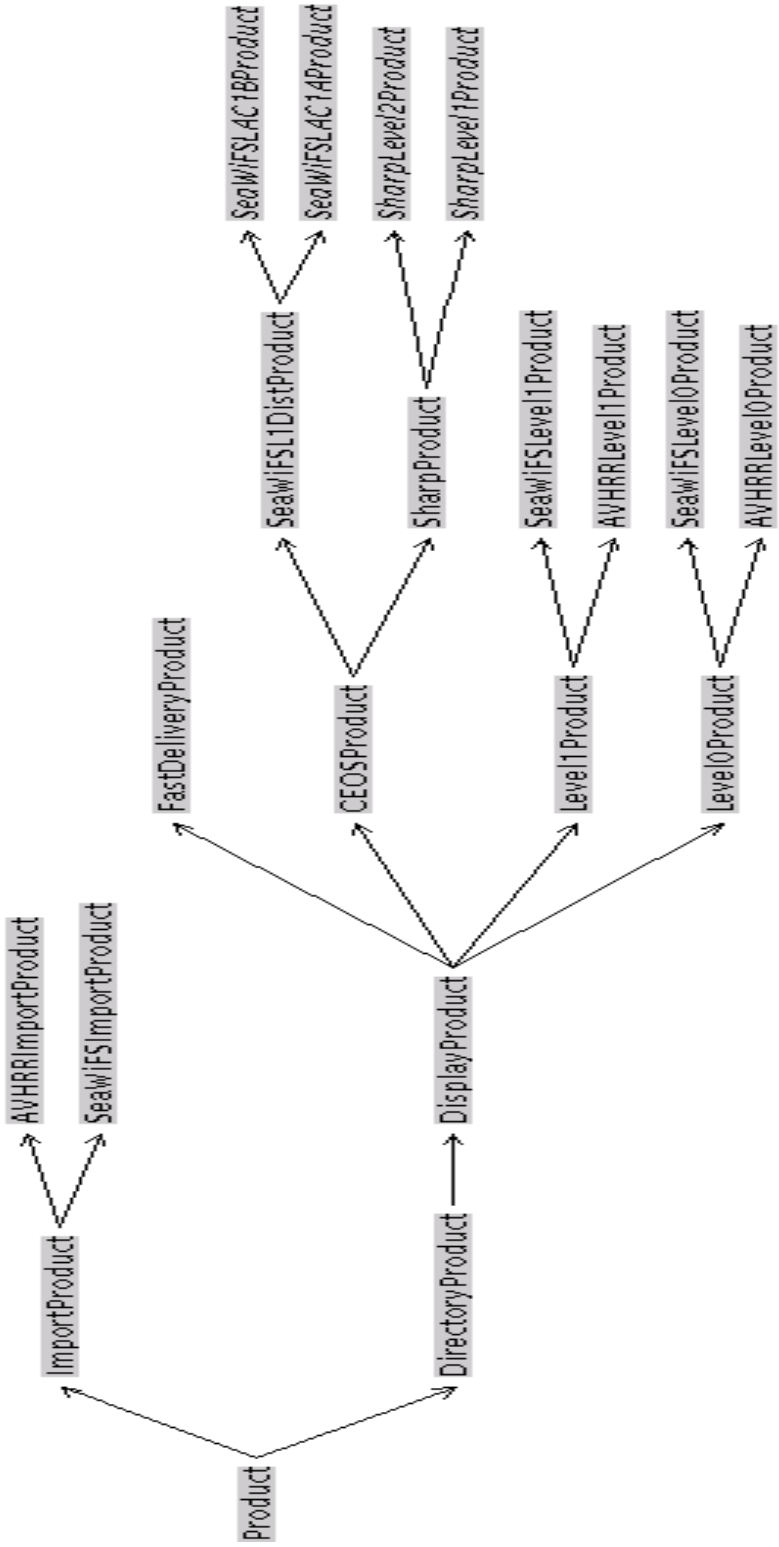


Figure A-6 Product hierarchy

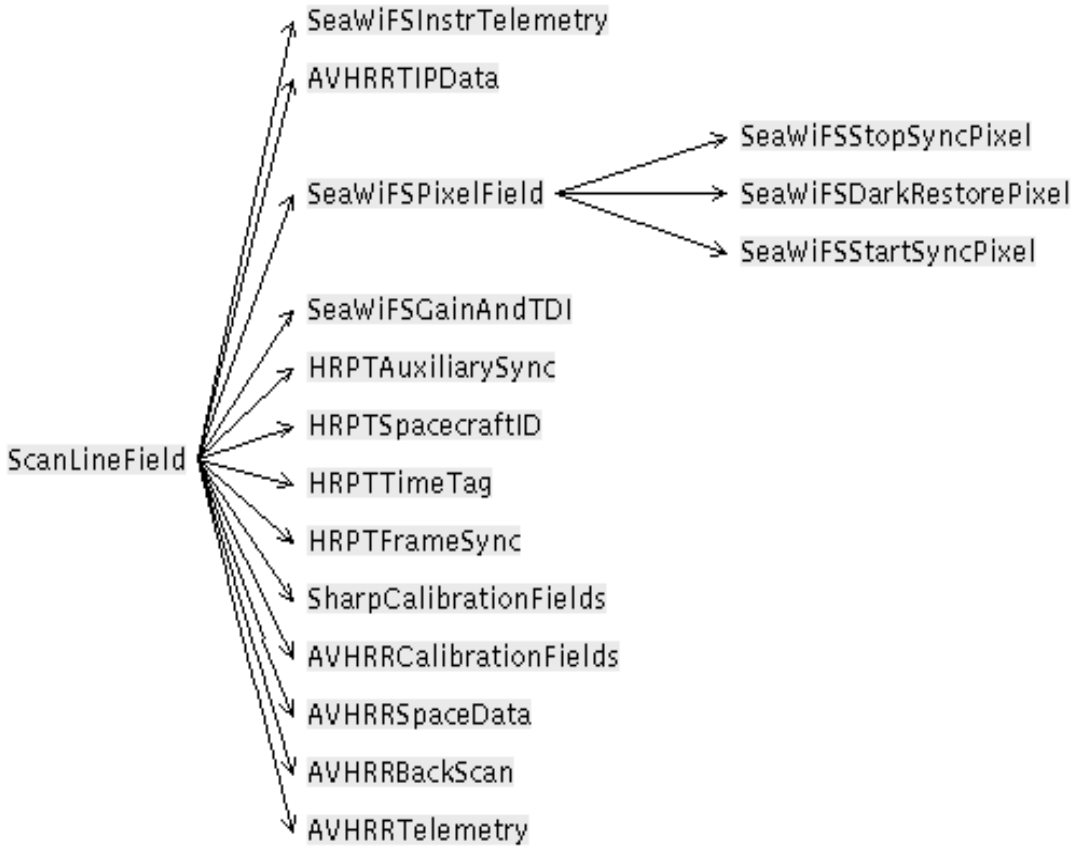


Figure A-7 ScanLineField hierarchy

A.2 Source Directory Structure

In the following section are a selection of diagrams describing the uses of the source sub directories.

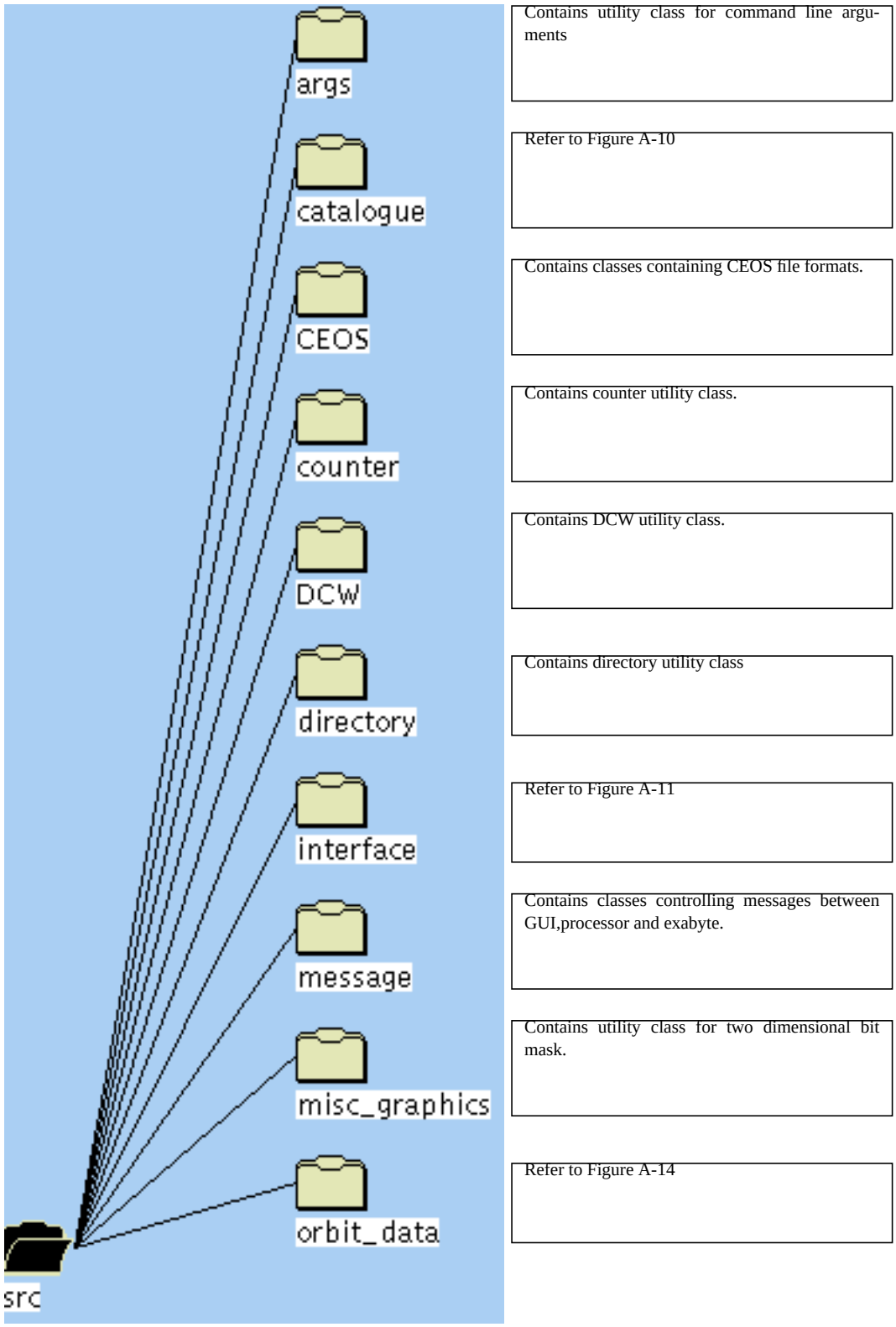


Figure A-8 Sub directories of top-level source directory

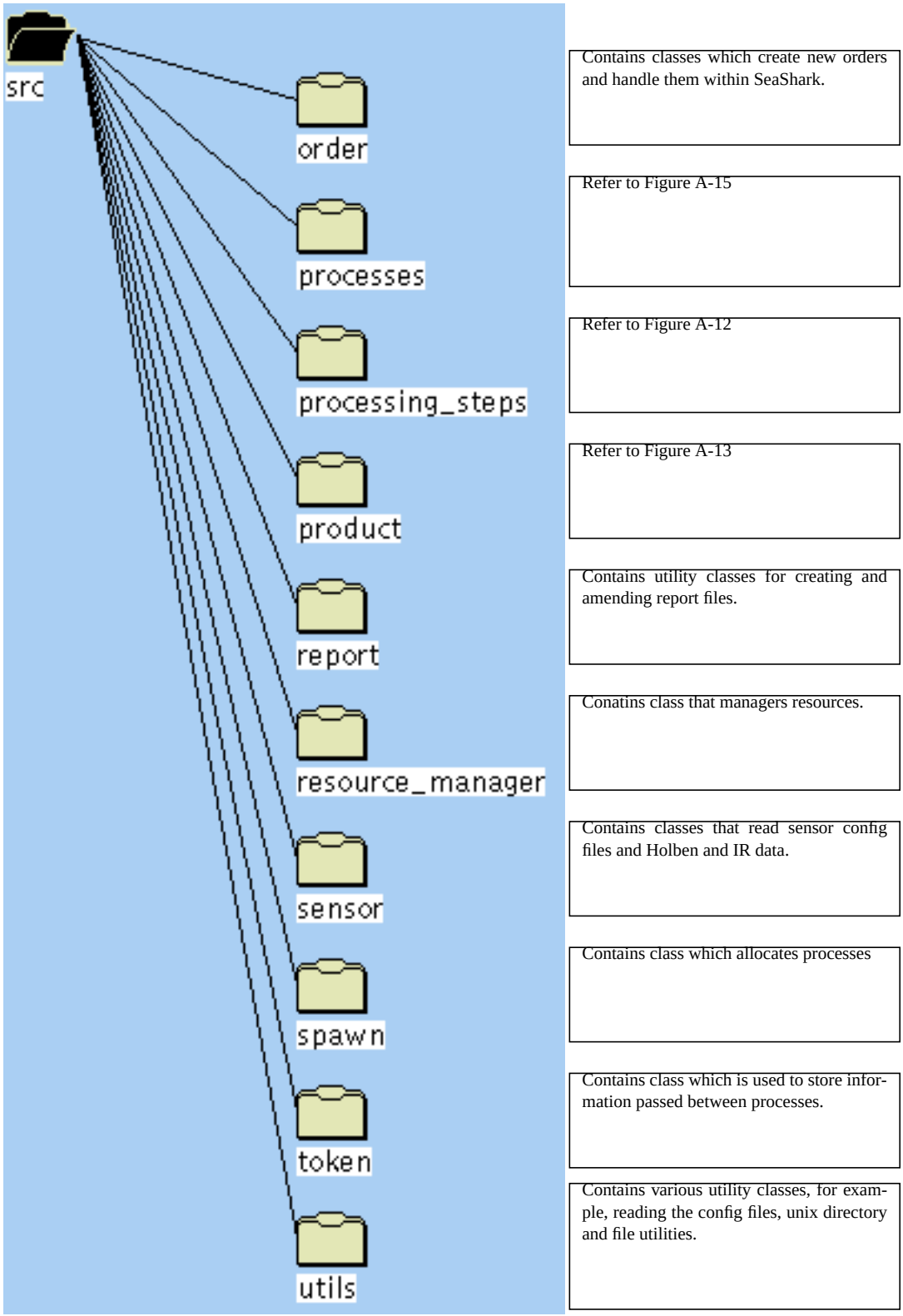

src
order
processes
processing_steps
product
report
resource_manager
sensor
spawn
token
utils
Contains classes which create new orders and handle them within SeaShark.
Refer to Figure A-15
Refer to Figure A-12
Refer to Figure A-13
Contains utility classes for creating and amending report files.
Conatins class that managers resources.
Contains classes that read sensor config files and Holben and IR data.
Contains class which allocates processes
Contains class which is used to store information passed between processes.
Contains various utility classes, for example, reading the config files, unix directory and file utilities.

Figure A-9 Sub directories of top-level source directory (continued)

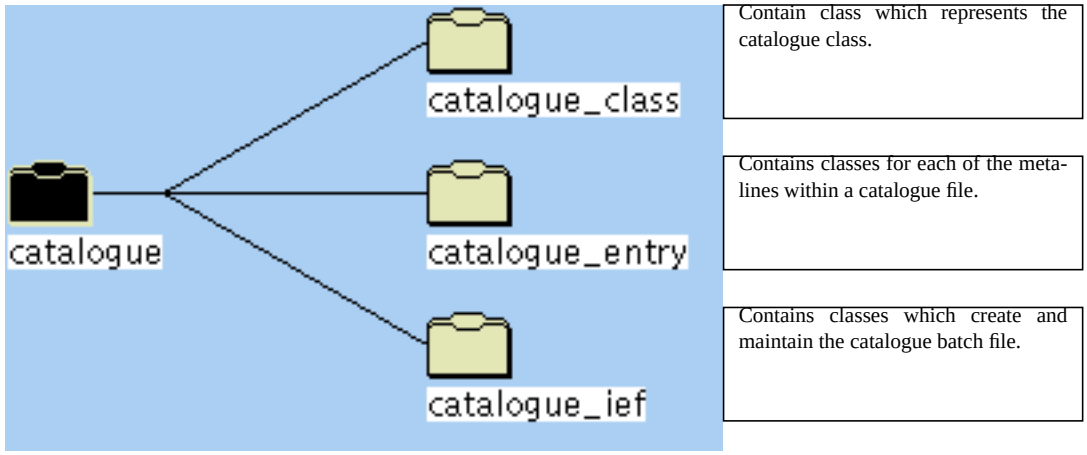

catalogue
catalogue_class
catalogue_entry
catalogue_ief
Contain class which represents the catalogue class.
Contains classes for each of the meta-lines within a catalogue file.
Contains classes which create and maintain the catalogue batch file.

Figure A-10 Catalogue sub directories

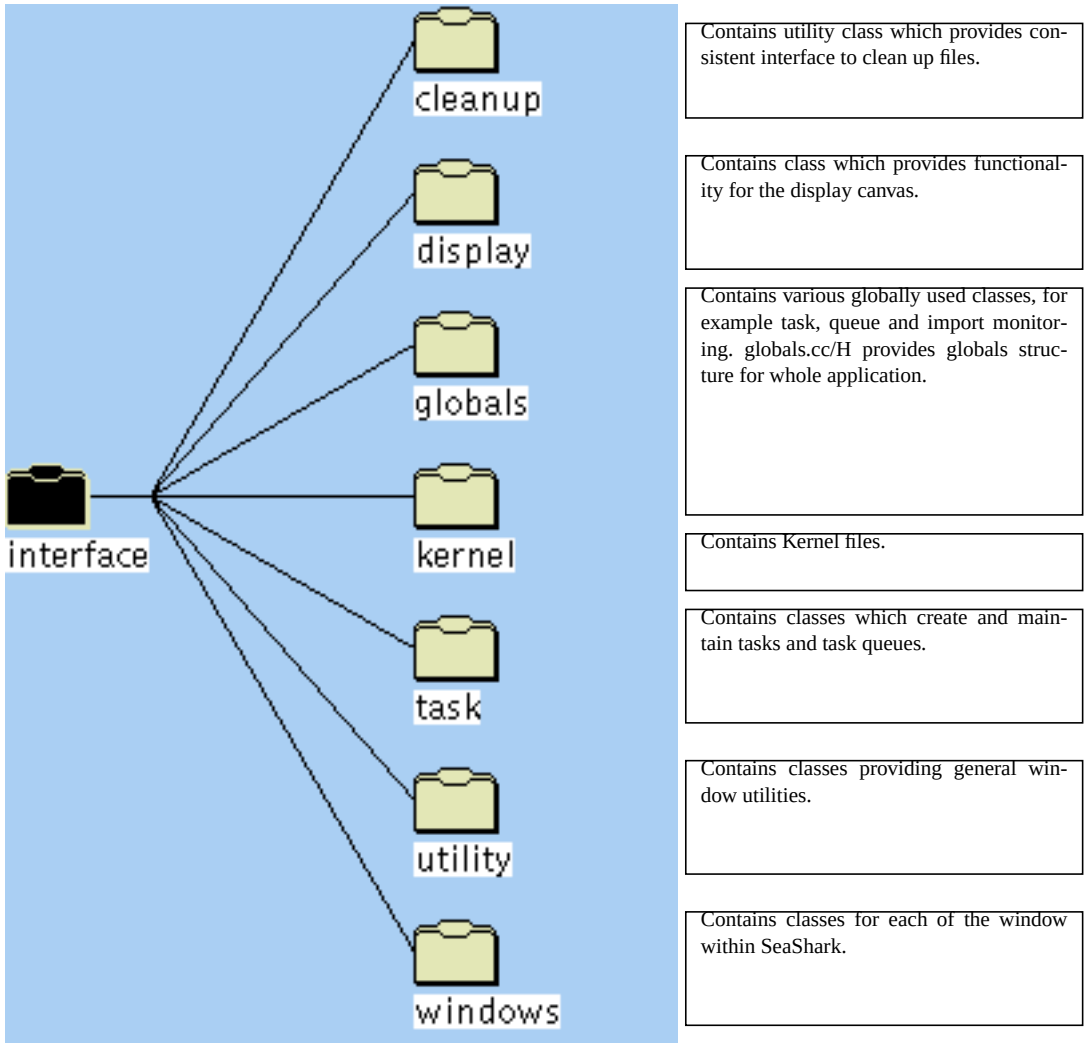

interface
cleanup
display
globals
kernel
task
utility
windows
Contains utility class which provides consistent interface to clean up files.
Contains class which provides functionality for the display canvas.
Contains various globally used classes, for example task, queue and import monitoring. globals.cc/H provides globals structure for whole application.
Contains Kernel files.
Contains classes which create and maintain tasks and task queues.
Contains classes providing general window utilities.
Contains classes for each of the window within SeaShark.

Figure A-11 Interface sub directories

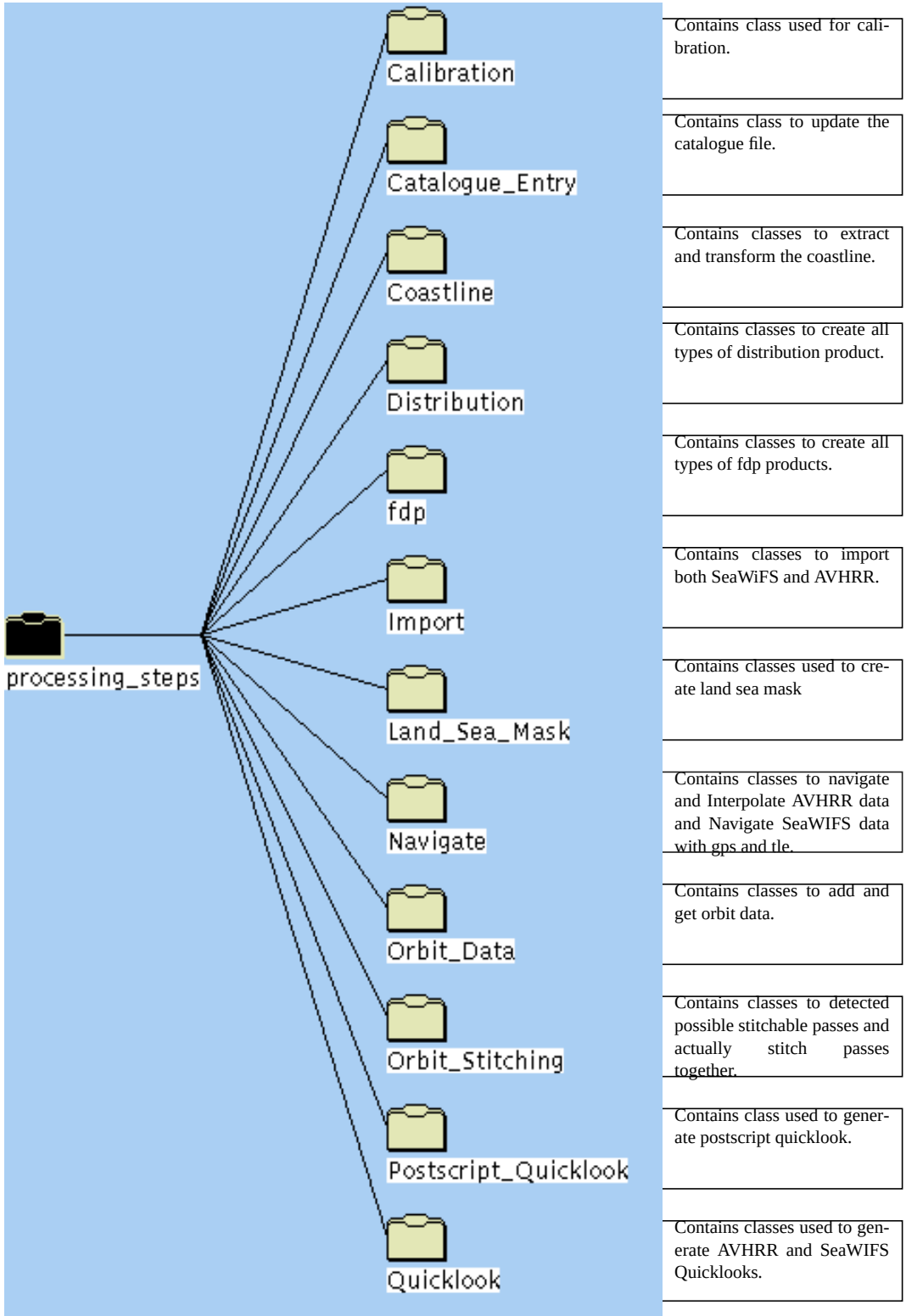

processing_steps
Calibration
Contains class used for calibration.
Catalogue_Entry
Contains class to update the catalogue file.
Coastline
Contains classes to extract and transform the coastline.
Distribution
Contains classes to create all types of distribution product.
fdp
Contains classes to create all types of fdp products.
Import
Contains classes to import both SeaWiFS and AVHRR.
Land_Sea_Mask
Contains classes used to create land sea mask
Navigate
Contains classes to navigate and Interpolate AVHRR data and Navigate SeaWIFS data with gps and tle.
Orbit_Data
Contains classes to add and get orbit data.
Orbit_Stitching
Contains classes to detected possible stitchable passes and actually stitch passes together.
Postscript_Quicklook
Contains class used to generate postscript quicklook.
Quicklook
Contains classes used to generate AVHRR and SeaWIFS Quicklooks.

Figure A-12 Processing_Steps sub-directories

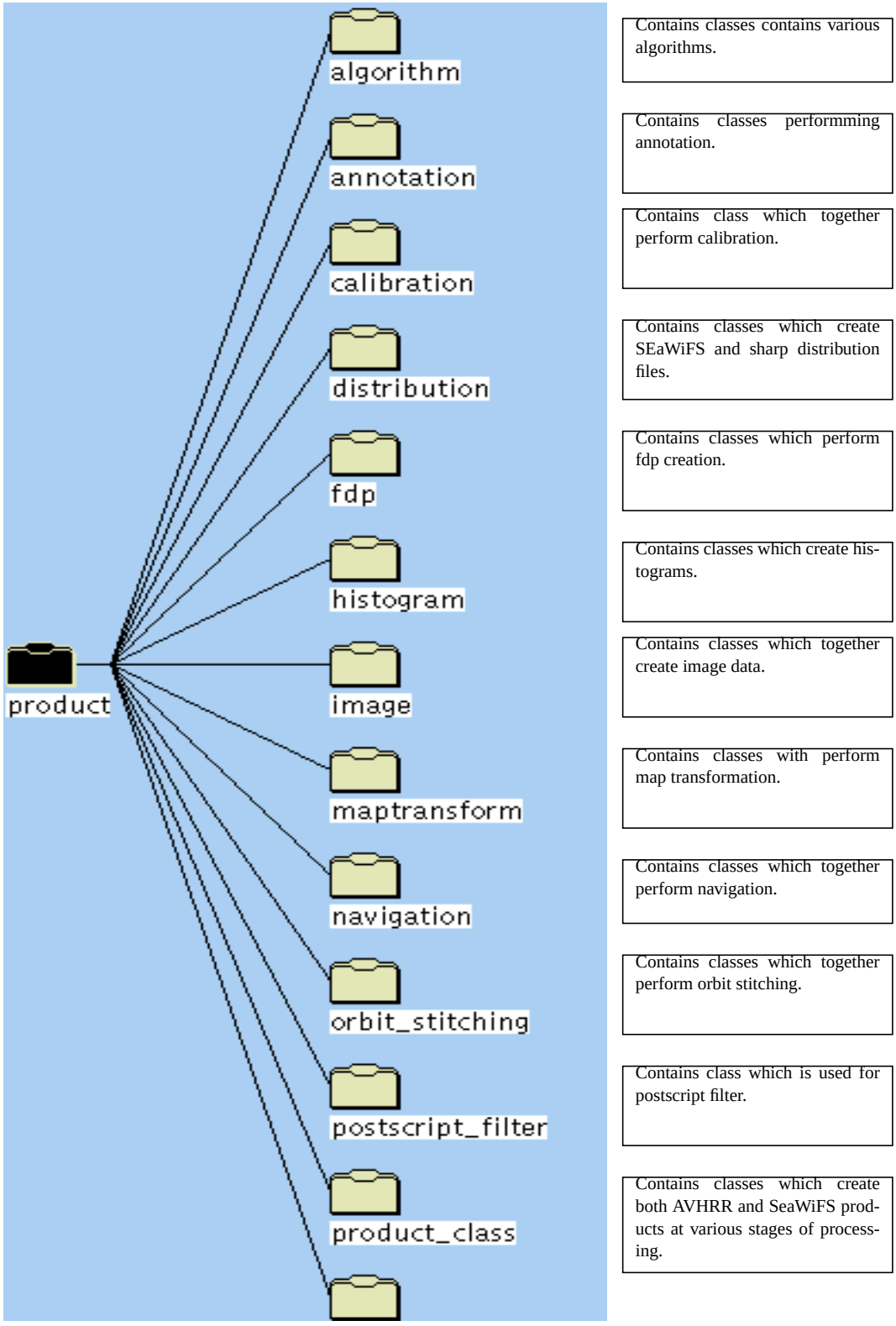


Figure A-13 Product sub directories

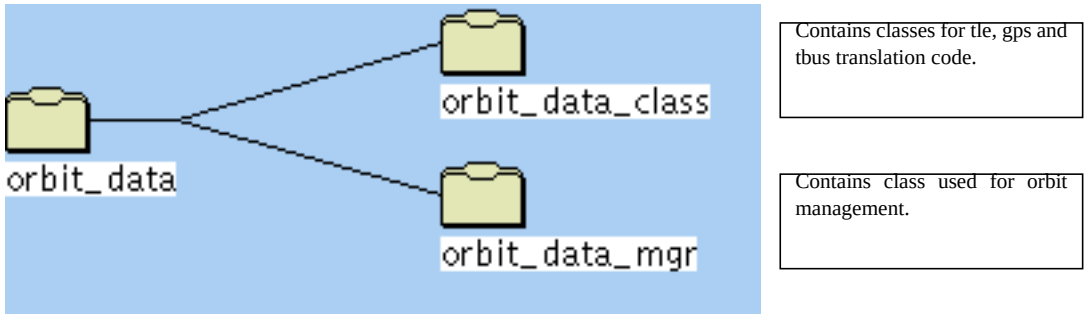


Figure A-14 orbit_data sub-directories

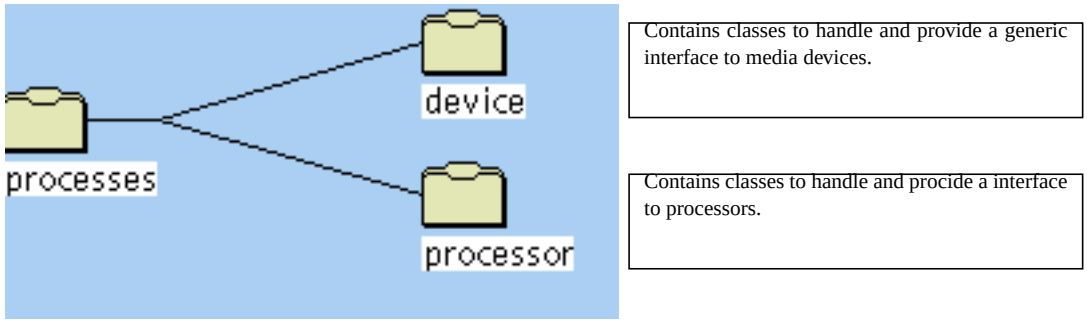

processes
device
processor
Contains classes to handle and provide a generic interface to media devices.
Contains classes to handle and procide a interface to processors.

Figure A-15 Processes sub-directories